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ABSTRACT

This monograph summarizes current scientific knowledge about attention deficit hyperactivity disorder (ADHD) in children and presents issues related to ADHD in gifted students. Causes, assessment, diagnosis, educational strategies and medical intervention are discussed. A range of perspectives, including behavioral, cognitive, and neurobiological, are applied to the interaction of ADHD and giftedness. Provisional recommendations for parents and teachers are provided along with directions for future research. Recommendations include: (1) be aware that ADHD and giftedness can co-exist; (2) explore multiple perspectives in your pursuit of information about ADHD; (3) remember that the most important criterion for diagnosing ADHD is the degree of impairment experienced by the child in two or more settings; (4) utilize a multidisciplinary team to arrive at diagnoses and to develop comprehensive treatment plans; (5) become familiar with a variety of educational and behavioral strategies to determine which combinations might be effective for the individual child; (6) be cautious about promises of "quick fixes"; and (7) be aware that individuals with ADHD have their greatest difficulties in the "output" stage of cognitive processing. Appendices include the diagnostic criteria for ADHD, a glossary of neurological terms, and user-friendly references and resources about ADHD. (Contains more than 200 references.) (CR)

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THE NATIONAL RESEARCH CENTER ON THE GIFTED AND TALENTED

Senior Scholars Series

University of Connecticut
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Attention Deficit Disorders and Gifted Students: What Do We Really Know?

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Attention Deficit Disorders and Gifted Students: What Do We Really Know?

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ABSTRACT

This monograph summarizes current scientific knowledge about Attention-Deficit/Hyperactivity Disorder (ADHD) in children and presents issues related to ADHD in gifted students. Causes, assessment, diagnosis, educational strategies and medical interventions are discussed. A range of perspectives, including behavioral, cognitive, and neurobiological, are applied to the interaction of ADHD and giftedness. Provisional recommendations for parents and teachers are provided along with directions for future research.

PREFACE

Few current topics in education have engendered as much attention, concern, and passion as Attention-Deficit/Hyperactivity Disorder (ADHD). The reasons surrounding the debate are many and varied. Some authors (Kohn, 1989; Reid, Maag, & Vasa, 1993) submit that ADHD has not been sufficiently documented as a valid diagnosis and should not be regarded as a disability category. Others (Armstrong, 1995; Freed & Parsons, 1997) suggest that ADHD is a social invention, a symptom of societal breakdown or a marketing ploy perpetrated by pharmaceutical companies (Breggin, 1998; Diller, 1998). Finally, others (Baum, Olenchak, & Owen, 1998; Lind, 1993; Rimm, 1999) characterize ADHD as a mismatch of curriculum and student or a misinterpretation of gifted, creative or "overexcitable" behaviors. A previous monograph in this series avoided these extremes by focusing exclusively on the potential for confusion between giftedness and ADHD, but suggested that such confusion may be the rule rather than the exception (Cramond, 1995).

One of the primary concerns about ADHD relates to the use of stimulant medications such as Ritalin® (generic name methylphenidate) to treat ADHD. Many studies have addressed aspects of those concerns but none has been conducted with gifted students. This is understandable since the dimension of giftedness is less crucial in the medical/physiological domain than in the educational/psychological realm.

In this monograph, we sought to understand the conjunction of giftedness and ADHD, with the assumption that such a combination is real. We recognize that giftedness is multifaceted and can be assessed in many ways other than a standardized IQ test. For the purposes of this monograph, however, giftedness is defined as advanced intellectual aptitude as measured by a standardized IQ test such as the Binet or the WISC-III. This is only to be able to make more discreet comparisons between children with average intellectual aptitude and children with documented high-aptitude, and how ADHD impacts the child who is gifted.

We wanted to summarize and differentiate between what is *known* and what is *assumed* about ADHD in gifted students. Recent neurobiological research on ADHD in gifted students suggests that giftedness and ADHD are two separate constructs that can exist within one child and that there are specific consequences for a child who manifests both giftedness and ADHD (Kalbfleisch, 2000).

Given our charge of presenting empirical research, we limited our discussion of the philosophical issues that surround the subject. Specifically, it is important to note that this monograph is not a discussion of gifted children with learning disabilities. In many cases, however, the diagnosis of ADHD is comorbid with the presence of a specific learning disability. The reader is referred to (Biederman, Newcorn, & Sprich, 1991; Shaywitz et al., 1995) for further information.

The discussion here will stretch along a continuum that covers the following: the historical context of ADHD, definition, etiology, risk factors and associated comorbidities, assessment and diagnosis, medical treatment, the coexistence of ADHD and giftedness, a theoretical perspective of executive function, creativity and ADHD, and, finally, educational strategies and behavioral interventions. The topics range in complexity and cover ADHD from multiple perspectives, including scientific discussions as well as practical applications. With this monograph, we

hope to encourage educators, parents, and educational researchers to engage in, support, and advocate for research studies on ADHD and giftedness.

(References are listed in the Executive Summary section.)

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EXECUTIVE SUMMARY

Few current topics in education have engendered as much attention, concern, and passion as Attention-Deficit/Hyperactivity Disorder (ADHD), particularly in gifted children (Baum, Olenchak, & Owen, 1998; Cramond, 1995; Lind, 1993; Rimm, 1999).

In this monograph, we sought to understand the conjunction of giftedness and ADHD, with the assumption that such a combination is real. We recognize that giftedness is multifaceted and can be assessed in many ways other than a standardized IQ test. We wanted to summarize and differentiate between what is *known* and what is *assumed* about ADHD in gifted students.

The monograph extends along a continuum that covers the historical context of ADHD, definition, etiology, risk factors and associated comorbidities, assessment and diagnosis, medical treatment, the coexistence of ADHD and giftedness, a theoretical perspective of executive function, creativity, and ADHD, and, finally, educational strategies and behavioral interventions. The topics range in complexity and cover ADHD from multiple perspectives, including scientific discussions as well as practical applications. By contrast, this summary merely presents brief highlights.

ADHD: History, Definition, and Etiology

What Is ADHD?

Attention-Deficit/Hyperactivity Disorder (ADHD) is a "syndrome," i.e., a grouping of symptoms that typically occur together. The core symptoms of ADHD are impulsivity, inattention, and hyperactivity (American Psychiatric Association, 1994). Estimates of the prevalence of ADHD among school age children vary but the median estimate across all definitions of ADHD and all types of studies is 2% in boys and girls combined (Lahey, Miller, Gordon, & Riley, 1999).

What Causes ADHD?

Family (Faraone & Biederman, 1998), adoption (summarized in Castellanos & Rapoport, 1992), and twin studies (Faraone & Biederman, 1998) demonstrate that genetic factors are very important in ADHD, but that environmental factors also play a significant role since heritability is less than 100%. Environmental factors, including premature birth (Lou, 1996), head injury (Max et al., 1998), fetal alcohol syndrome (Steinhausen, Willms, & Spohr, 1993; Streissguth, Barr, Sampson, & Bookstein, 1994), prenatal exposure to drugs of abuse, such as cocaine (Griffith, Azuma, & Chasnoff, 1994; Levitt, Harvey, Friedman, Simansky, & Murphy, 1997; Vogel, 1997), lead toxicity (Needleman et al., 1979), prenatal maternal smoking (Denson, Nanson, & McWatters, 1975; Milberger, Biederman, Faraone, Chen, & Jones, 1996; Nichols & Chen, 1981), and rare endocrine abnormalities (Hauser et al., 1993; Matochik, Zametkin, Cohen, Hauser, & Weintraub, 1996) can all cause the ADHD syndrome.

How Is ADHD Assessed and Diagnosed?

Four subtypes of Attention-Deficit/Hyperactivity Disorder are recognized in the DSM-IV: Predominantly Hyperactive/Impulsive, Predominantly Inattentive, Combined, and Not Otherwise Specified (American Psychiatric Association, 1994). To meet the criteria for one of the specific subtypes, at least 6 of the 9 symptoms of hyperactivity/impulsivity, or at least 6 criteria from the 9 symptoms of inattention must be present. (Combined type means both sets of criteria are met.) The symptoms must occur *in more than one setting*, must persist for *at least 6 months*, and must affect the individual "to a degree that is *maladaptive and inconsistent with developmental level*" (American Psychiatric Association, 1994, p. 83).

The diagnostic criteria for ADHD emphasize that "there must be clear evidence of *clinically significant impairment* in social, academic, or occupational functioning" (American Psychiatric Association, 1994, p. 84). Moreover, some impairing symptoms must be present before 7 years of age.

Under optimal circumstances, a team, *including a qualified clinician*, such as a pediatrician, family physician, psychiatrist, neurologist, or psychologist should make the diagnosis of ADHD because only these types of specialists can assess the aforementioned physical and psychological problems that mimic ADHD. Information about these conditions is rarely available to school personnel, no matter how observant, experienced, or well trained.

For the majority of children with ADHD, symptoms become clear-cut when their behavior can be observed regularly and compared to other children over a sustained period. The classroom teacher, therefore, is typically the best person to make such comparisons, especially when systematic behavioral checklists or rating scales are employed. When the child in question is gifted, an individual who specializes in giftedness should also be included in the process to provide information about the child's behavior in comparison to other children of similar abilities (Silverman, 1998).

There is widespread concern about the "overdiagnosis" of ADHD. However, when assessment involves experienced clinicians, working to integrate information from multiple sources, particularly from teachers, the end product can be remarkably

reliable and valid. Such a comprehensive assessment requires sufficient time, and much of the current dissatisfaction may be traced to trends in health care that lead to a brief or even instant diagnosis. We believe that when such shortcuts are taken, the main problematic result is not generally the misdiagnosis of a "perfectly normal" child as having ADHD. Instead, what happens is that other comorbid problems, such as the ones discussed above, are missed and go untreated by clinicians and unremediated by educators.

Researchers continue to pursue objective tests for ADHD. But even the most advanced and promising of these techniques (Cox et al., 1998; Dougherty et al., 1999; Krause, Dresel, Krause, Kung, & Tatsch, 2000; Monastra et al., 1999; Monastra, Lubar, & Linden, in press) is still not able to answer the question that is central to this monograph: *How can we objectively differentiate whether a child has ADHD when he or she is also gifted?*

ADHD or Gifted: Either or Both?

In recent years, several authors (Baum et al., 1998; Cramond, 1995; Freed & Parsons, 1997; Lind, 1993; Tucker & Hafenstein, 1997; Webb & Latimer, 1993) have expressed concern that giftedness is often misconstrued as ADHD and that the diagnosis of ADHD among the gifted population has run amok. We acknowledge for the purposes of this discussion that there are cases of mistaken diagnosis, although as of this writing, we have found ***no empirical data*** in the medical, educational, or psychological literature to substantiate the extent of this concern. The lack of scientific data heightens our dismay over the wave of skepticism that appears to prevail about the existence of ADHD in gifted children. Specifically, we are concerned that the question "ADHD or gifted?" dismisses the possibility that the two conditions may coexist. Prudent attempts to avoid over-diagnosis must be balanced against a child's need for evaluation and treatment in the context of inevitable uncertainty when medical diagnoses are invoked.

In this context, Silverman (1998) notes that some professionals erroneously assume that a child who demonstrates sustained attention, such as a gifted child engaged in a high-interest activity, cannot have ADHD. It is understandable that an observer might discount the possibility of ADHD because from all appearances the child is so absorbed in a task that other stimuli fade into oblivion. While this state of rapt attention is often described as "flow"(Csikszentmihalyi, 1990), it can also be ascribed to "hyperfocus," which is a similar condition that individuals with ADHD frequently experience (Hallowell & Ratey, 1994).

Activities that are continuously reinforcing and "automatic," such as video or computer games or reading for pleasure, do not distinguish children who have ADHD from children who do not have ADHD, whereas effortful tasks do (Borcherding et al., 1988; Douglas & Parry, 1994; Wigal et al., 1998). By virtue of their giftedness, the range of tasks that are perceived as "effortless" is broader for gifted children, which is why their ADHD may be less apparent than in children who struggle more obviously and to lesser effect.

Recent work (Kalbfleisch, 2000) suggests that the gifted child with ADHD is particularly predisposed to exhibit this state of "flow" or "hyperfocus." While this can be a positive aspect of task commitment and a sign of motivation, it becomes a problem when the child is asked to shift from one task to another. Therefore, while

cognitively this state can have positive aspects, behaviorally it can also cause problems (Moon, Zentall, Grskovic, Hall, & Stormont, in press). Furthermore, ADHD is not characterized by an *inability* to sustain attention, but rather by the inability to appropriately regulate the application of attention to tasks that are not intrinsically rewarding and/or that require effort. Such tasks are, sadly, characteristic of much of the work that is typically required in school, even in programs for gifted students.

While a misdiagnosis of ADHD is undesirable, diagnostic errors of omission are just as serious and may be even more prevalent among gifted students. This difficulty occurs when a student's over-reliance on strengths inadvertently obscures the disability. While emphasizing strengths may highlight a student's gifts and talents, it does not eliminate the reality of the condition and can, in fact, lead to a worse predicament in which the student distrusts his or her abilities because of the struggle to maintain them. On the other hand, if a student is allowed to acknowledge and experience the disability, he or she may learn appropriate compensatory or coping skills.

We believe that acknowledging that a child can be both gifted and have ADHD and that exploring the ways in which these conditions might interact in each child is a more productive way of looking at the problem than agonizing about a false dichotomy.

Given the realities of the co-existence of giftedness and ADHD, the question should not be "ADHD or gifted?" but rather "how impaired is this student by his/her ADHD?" Some children are able to compensate in most situations for their ADHD (and neither they nor their parents or teachers may be aware of it); others are seriously handicapped. The single most relevant element that must be considered in evaluating ADHD is the degree of *impairment* a child experiences as a result of the behaviors.

A child whose behavior causes him/her to be impaired academically, socially, or in the development of a sense of self, should be examined from a clinical/medical perspective to exclude potentially treatable conditions, even if the behavior may be similar to the traits typically ascribed to creativity or giftedness (Cramond, 1995) or to "overexcitabilities" (Piechowski, 1997; Silverman, 1993). However, this does not mean that every child who is impaired needs medication. As many authors have noted (Diller, 1998; Flick, 1998; Hartmann, 1993; Lerner, Lowenthal, & Lerner, 1995), non-medical interventions can be used within the school and home and should be tried before more intrusive interventions are employed.

Is ADHD Included in Special Education Laws?

The 1999 reauthorization of the Individuals with Disabilities Education Act explicitly recognized, for the first time, ADHD (and ADD) as disorders that should be classified as Other Health Impaired, when they adversely affect a child's educational performance. The reader is referred to http://www.chadd.org/legislative/govt.htm for further detailed information and relevant hyperlinks.

ADHD and Giftedness: Where Do We Go From Here?

Clearly, this monograph must conclude with a plea for additional empirical research on giftedness and attention deficit disorders. Questions such as incidence of DSM-IV subtypes of ADHD among the gifted population must be investigated before other types of research can proceed. If such research were to show that current DSM-IV criteria identify significantly different proportions of gifted students compared to the general population (over or under diagnosis), subsequent studies would be able to explore the sources and characteristics of the discrepancies. The availability of data would in turn facilitate and encourage the development of strategies for appropriate identification and curriculum.

The information in this monograph is not intended to implicate ADHD as a defect that must be "cured." In fact, our experience of many gifted children with ADHD resonates with our colleagues' perceptions that the condition can not only inhibit, but enhance the realization of gifts and talents.

Educators of gifted students with ADHD face a formidable task in that they must provide opportunities for students to apply their strengths while ameliorating their deficits. Although the same might be said of any sound educational program, this is more daunting for gifted students with ADHD because of the striking disparities these conditions can create. Only through consistent attention, immeasurable creativity, and enduring patience by educators, parents, and students, coupled with substantive research, can these challenges be adequately addressed.

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Attention Deficit Disorders and Gifted Students: What Do We Really Know?

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PART I. ADHD: History, Definition, and Etiology

Seal up the mouth of outrage for a while
Till we can clear up these ambiguities.

William Shakespeare, Romeo and Juliet

Matthew, age 14

- My mind wanders but, because I'm gifted, it wanders into real subjects—it's not like wandering off into nothing. I'm not daydreaming, I'm thinking. Like when I'm in science, my mind wanders and I just start thinking about another thing related to science or something related to another class.

Michael, age 18

- In high school I got almost all A's. But to write a 3 - 5 page paper, which is the standard length at my school, it would take my friend maybe 3 to 4 hours to do a thorough job but it takes me 18 hours. What happens is a combination of the actual paying attention and the frustration that comes when you lose attention. If I am reading a book, I often have to go back and read the same lines over and over again to make them make sense, and I might start daydreaming. The other loss of concentration is when you read a line but nothing really sinks in. It doesn't really have any meaning to you so you have to go back and do it again. I can remember sitting in English class while everyone is writing their homework for the next day and I just pick a word and stare at it for 45 minutes. It's not that I can't do it, I just can't bring myself to start. It becomes so frustrating that sometimes you just want to give up.

Kevin, age 16

- Being gifted with ADHD has been both a blessing and a curse. The more obvious of the two is the blessing. Having the ability to accomplish work (homework, projects, etc.) without putting forth much thought has pulled me through countless classes. On the other hand, the ADHD has always limited my capabilities to work long lengths of time or consistently throughout the year. What normally took a student an hour would take me only a fraction of the time. Never needing an explanation or extra time to figure things out allowed my ADHD to thrive in an environment where 100% effort was never needed. I could play after school, watch TV, do anything and still finish the essential homework assignments for the next day. For a long while, being gifted was enough. It took care of the ADHD because my school effort never intruded into my play-time effort.

How Has the Concept of ADHD Evolved?

While the term "Attention-Deficit/Hyperactivity Disorder" is relatively new, the syndrome has been discussed in medical, educational, psychological, and popular literature for many years. One of the earliest known descriptions of the symptoms appeared in 1845 in *Moral Tales*, which described a disobedient and unsettled child named Fidgety Phil, whose lack of discipline and incorrigible behavior was attributed to ineffective parenting (Lerner, Lowenthal, & Lerner, 1995). Half a century later, a physician named Still observed the same characteristics in his patients but ascribed their symptoms ("morbid defects in moral control") to biology rather than environment. Following a post-World War I encephalitis epidemic in which many soldiers showed similar symptoms, brain damage was cited as the cause and was implicated in the literature for several subsequent decades (Lerner et al., 1995).

The disturbing label "brain damage" provoked protest and resistance, especially among parents. In response, researchers created the terms "minimal brain damage"

and "minimal brain dysfunction," which allowed parents, teachers, and physicians to distinguish between severe or traumatic brain damage and less catastrophic conditions. While these terms were less objectionable, they were never officially adopted as psychiatric terminology.

The term "hyperkinetic reaction of childhood" was incorporated into the 1968 Diagnostic and Statistical Manual of Mental Disorders (DSM-II) of the American Psychiatric Association, but lacked precise diagnostic guidelines. In the 1970's, as the predominant style of psychiatric research shifted away from the psychoanalytic approach, a "new paradigm" was developed. The pioneers of this process, grounded in the empiricism of psychology and other social sciences, recognized a need for observable diagnostic criteria, particularly for research purposes. These so-called Research Diagnostic Criteria (Feighner et al., 1972) became the basis for subsequent versions of the DSM and culminated in the current DSM-IV criteria (American Psychiatric Association, 1994), which are included in Appendix A.

What Is ADHD?

Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common neuropsychiatric disorder of childhood (American Psychiatric Association, 1994). It is not a single disease, but a "syndrome," i.e., a grouping of symptoms that typically occur together. The core symptoms of ADHD are impulsivity, inattention, and hyperactivity. These symptoms and related problems can be mild, moderate or severe, and may manifest in different combinations within familial, academic and social contexts.

Estimates of the prevalence of ADHD among school age children vary from 0% to 16% (Lahey, Miller, Gordon, & Riley, 1999), a range that reflects differences in research methodology as well as the heterogeneity and complexity of the condition itself. The median estimate across all definitions of ADHD and all types of studies is 2% in boys and girls combined (Lahey et al., 1999). The symptoms typically emerge in early childhood and frequently continue into adulthood, although the manifestations of the condition change over time (Biederman, 1998).

What Causes ADHD?

Broadly speaking, there are three types of causes for any medical condition, whether the condition is high blood pressure, diabetes, or ADHD. These are genetics, environment, or interactions between the two. The contribution of each of these factors is usually determined through *family*, *adoption*, and *twin* studies, each of which provides different and useful types of data. The following is an overview of these types of investigations as they relate to ADHD.

Family studies confirm that the chances that an individual will have ADHD is at least five times higher if he or she is closely related (sibling, parent, or child) to someone who also has ADHD (Faraone & Biederman, 1998). Recent research (Barkley, 1997a) reveals that a child of a parent with ADHD has up to a 50% chance of having the condition. Adoption studies also reveal greater similarities between children with ADHD and their biological parents than between those children and their adoptive parents (Castellanos & Rapoport, 1992). Taken together, these investigations point to genetics as a major cause of the disorder.

While family investigations confirm the role of inheritance in the transmission of ADHD, twin studies reveal the *extent* of genetic influences. Studies comparing the degree of similarity (concordance) between identical twins and fraternal twins consistently converge on estimates of the heritability of ADHD ranging from 75% to 90% (Faraone & Biederman, 1998). In other words, twin studies demonstrate that genetic factors are very important in ADHD, but that environmental factors also play a significant role since heritability is less than 100%.

Nature: What Genes Are Associated With ADHD?

Literally thousands of medical conditions are caused by or associated with variations in single genes. Some conditions, such as sickle cell disease or cystic fibrosis, manifest only when *both* copies of a particular gene are defective while other conditions, such as Huntington's Chorea, may occur when only a *single* copy of the disease gene is present. These conditions are respectively known as recessive or dominant disorders.

Unlike these conditions, psychiatric disorders fall into a category of *complex genetic disorders* that are probably associated with *several* genes, each of which contributes to enhanced vulnerability for a particular disorder. Thus, it is doubtful that a single gene will be found to "cause" ADHD. Instead, a *number of genes* that increase the *probability* of ADHD will likely be implicated.

What Are the Current Candidate Genes in ADHD?

Since ADHD is a heterogeneous condition, different combinations of genes may cause the various types of ADHD. Current research has focused on several "candidate genes," two of which are part of the dopamine system that regulates attention, physical activity, motivation, and reward.

Several different groups (Cook, Jr. et al., 1995; Gill, Daly, Heron, Hawi, & Fitzgerald, 1997) have found an association between ADHD and a variation of the gene that contains the "construction blueprints" for the *dopamine transporter* (DAT1).[1] Likewise, researchers have found an association between the D4 dopamine receptor (DRD4),[2] the gene that codes for one specific type of *dopamine receptors*, and ADHD (LaHoste et al., 1996; Rowe et al., 1998; Smalley et al., 1998; Swanson et al., 1998). Although this is the most replicated finding in psychiatric genetics (Swanson et al., 2000), some studies (Castellanos et al., 1998) failed to find the predicted association, perhaps because the gene increases the risk of ADHD by only 50% (which means that the effect would be imperceptible in a small scale study.)

If large collaborative studies (Asherson et al., 2000) confirm that DAT1 and DRD4 are associated with ADHD, other candidate genes will still need to be considered.

---

[1] The dopamine transporter (DAT1) removes the neurotransmitter dopamine from the synapse after its release and thus terminates its effect. Ritalin (methylphenidate) fits into the dopamine and norepinephrine transporters and blocks dopamine and norepinephrine from being recycled. This increases the effective signal of these "neuromodulators."

[2] There are 5 distinct dopamine receptor types. The most common are D1 and D2. D4 receptors are found in inhibitory cells in the prefrontal cortex, in globus pallidus, and cerebellum, all of which are associated with attention and self-regulation.

since the effects of these two genes appear to be modest at best. Thus, the presence of one or both of these candidate genes does not ensure that an individual will have ADHD.

As the *Human Genome Project*[3] and related studies progress, investigators will be able to examine nearly all human genes, some of which are likely to be revealed as contributors to ADHD. Even then, however, it is unlikely that "genes that *cause* ADHD" will be found. Instead, researchers will attempt to locate the genes that *increase the risk of developing* ADHD. Moreover they will continue to investigate environmental factors that also increase the risk for ADHD. Some of these are described in the following section.

Nurture: What Environmental Factors Increase the Risk of ADHD?

Environmental factors, including premature birth, head injury, fetal alcohol syndrome, prenatal cocaine and smoking, lead toxicity, and high levels of psychosocial stress have been linked to ADHD. A thorough review of the literature on these topics is beyond the scope of this monograph; however, the following paragraphs summarize the most salient points. A glossary of terms related to brain anatomy, physiology, and neurology is included in Appendix B.

Premature Birth

One of the greatest hazards to the developing brain is premature birth. While the entire brain is at risk in very low-birth-weight infants (birth weight less than 2.2 pounds), the *basal ganglia* are particularly vulnerable because of their precarious blood supply. When bleeding and/or loss of oxygen (anoxia) in the brain is severe, cerebral palsy is likely; less severe bleeding and/or oxygen loss (hypoxia) frequently cause learning disabilities and ADHD (Lou, 1996).

Head Injury

Children and adolescents with ADHD are more accident prone than those without ADHD (Gayton, Bailey, Wagner, & Hardesty, 1986; Pless, Taylor, & Arsenault, 1995). Severe head injury can produce an onset of ADHD symptoms, even among those who do not have ADHD before their accident (Max et al., 1998).

Fetal Alcohol Syndrome

While severe alcohol use during pregnancy is most often associated with Fetal Alcohol Syndrome, less severe cases can produce profound learning disabilities, diminished intelligence quotients, and ADHD (Steinhausen, Willms, & Spohr, 1993; Streissguth, Barr, Sampson, & Bookstein, 1994).

Prenatal Cocaine

Prenatal use of cocaine is highly toxic for the developing brain (Griffith, Azuma, & Chasnoff, 1994; Levitt, Harvey, Friedman, Simansky, & Murphy, 1997; Vogel, 1997), although it is difficult to separate which detrimental effects are due to cocaine and which are due to co-existing conditions such as poverty and poor maternal

[3] The Human Genome Project has been compared to the Apollo project's trip to the moon. The goal is to produce a complete "map" of human DNA with the precise location and sequence of all human genes. This greatly facilitates the momentous task of understanding the functions of all human genes and the implications of their variations.

education (Mayes, Granger, Bornstein, & Zuckerman, 1992; Richardson & Day, 1994).

Lead Toxicity

Lead is toxic to the brain, and can cause behavior problems, including ADHD (Needleman et al., 1979). Recent studies, however, have failed to support a strong link between lead toxicity and ADHD (Dietrich, Succop, Berger, Hammond, & Bornschein, 1991; Tuthill, 1996). Fortunately, the relevance of this controversy has decreased as lead levels in children have declined.

Prenatal Smoking

While lead toxicity in children is decreasing, the rate of smoking in women of reproductive age continues to increase. This is unfortunate, since maternal smoking during pregnancy increases the risk of ADHD and associated behaviors (Denson, Nanson, & McWatters, 1975; Milberger, Biederman, Faraone, Chen, & Jones, 1996; Nichols & Chen, 1981). In laboratory rats, the effects of prenatal nicotine exposure differ in males and females (Popke, Tizabi, Rahman, Nespor, & Grunberg, 1997), which is compatible with the finding that ADHD affects more males than females.

Dietary Causes

Despite many attempts to empirically confirm the relationship of sugar consumption to ADHD, no such association has been found in any placebo-controlled studies (Behar, Rapoport, Adams, Berg, & Cornblath, 1984; Kinsbourne, 1994; Krummel, Seligson, & Guthrie, 1996; Wolraich et al., 1994; Wolraich, Wilson, & White, 1995). Food allergens, however, may provoke ADHD symptoms in a few children (Egger, 1991; Egger, Carter, Soothill, & Wilson, 1992; Egger, Stolla, & McEwen, 1992; Uhlig, Merkenschlager, Brandmaier, & Egger, 1997).

The continuing concern about the possibility of a link between diet and ADHD was recently highlighted in a review published by the Center for Science in the Public Interest (Jacobson & Schardt, 1999). The report argued that many of the studies that examined the relationship between hyperactive behaviors and certain foods or food additives (such as food colorings) were limited by factors such as small sample size and poor design. The report (www.cspinet.org/new/adhdpr.html) requested that the FDA require more comprehensive research in this area.

Endocrine Causes

A number of rare conditions appear to be associated with ADHD, including generalized resistance to thyroid hormone (Hauser et al., 1993; Matochik, Zametkin, Cohen, Hauser, & Weintraub, 1996). It is now well established that, except for these extremely rare families, thyroid abnormalities are not associated with ADHD (Elia, Gulotta, Rose, Marin, & Rapoport, 1994).

Because ADHD is not a unitary condition, many rare subtypes associated with specific genetic or environmental factors will undoubtedly be discovered. In addition, research about brain development, anatomy and physiology continues to reveal significant information about the brain regions involved in ADHD. In the following section, we will review some of the more accessible aspects of this complex and formidable area of research.

Summary of Part I

Although the current definition of ADHD is not definitive, it has undergone successive refinement, and is currently one of the most reliable psychiatric diagnoses when performed conscientiously. There are a number of potential causes of ADHD, but the most important factor appears to be genetic predisposition.

In the next part, we will summarize current neurobiological concepts of ADHD, starting with a systems perspective on the relevant brain circuits, followed by a hypothesis regarding the possible "engine" for the dysfunctions present in ADHD. We will also explain the probable role of the "fuel" for attention and self-regulation, dopamine, and close with a discussion of cognition with regard to executive function.

PART II. Neurobiology and Psychology of ADHD

The System: What Brain Circuits Are Involved in ADHD?

Studies of brain anatomy and physiology in ADHD (Berquin et al., 1998; Casey et al., 1997; Castellanos et al., 1996a; Castellanos, 1997a; Ernst, Zametkin, Matochik, Jons, & Cohen, 1998; Filipek et al., 1997) have focused on dysfunction in one specific brain circuit, the *prefrontal-basal ganglia circuit*. According to the currently dominant theory, the prefrontal-basal ganglia circuit, which links *prefrontal cortex* with the basal ganglia, is compared to a switching device. The anatomy of this circuit suggests that information from the cortex can travel through the basal ganglia via one of two pathways. The *direct pathway* amplifies and redirects information, sending it to other cortical regions for further processing or action (such as movement), while the indirect pathway is believed to counterbalance and inhibit the unwanted impulses. When targeted movement or action is required, however, the inhibitory circuit is temporarily muted, and the excitatory circuit "wins."

Studies in rhesus monkeys (Goldman-Rakic, Bourgeois, & Rakic, 1997), and a unique study in children (Chugani, Phelps, & Mazziotta, 1987), imply that the balance between excitation and inhibition changes as children mature (Castellanos, 1997b). As maturation proceeds, unnecessary excitatory connections are deleted, gradually bringing excitation and inhibition into balance in early adulthood.

From this perspective, ADHD can be thought of as an imbalance between excitation and inhibition, beyond what would be expected for a given age or developmental level. The easiest way to observe the results of an imbalance between excitation and inhibition is to watch an infant attempt to capture an interesting object. At first, the infant's limbs only occasionally strike the object, perhaps with the back of the hand, rather than with the palm. The movements become more orchestrated and more precise, as the infant eventually learns to inhibit all but the specific muscles required to reach the target.

Like an infant, a child with ADHD displays dysregulation of inhibitory faculty. Appropriate inhibition can occur, but only with the exertion of extra effort, which makes it especially difficult for the child to *consistently* control his or her behavior. When a new, unrelated stimulus appears, he/she may not be able to shift the prior focus. The almost overwhelming effort required to stay on task may be too frustrating and lead the child to act impulsively. The child's handwriting may become irregular and sloppy because it takes additional effort to inhibit extraneous movements. The child may be more active motorically than peers because it is too difficult to "rev down" after being stimulated.

The model described briefly above has the advantage of simplicity and it is heuristically useful, but it may well be too simplistic to encompass this complex circuitry. The reader is referred to other more textured discussions (Brown, Bullock, & Grossberg, 1999; Graybiel, 1998; Middleton & Strick, 2000) for more information.

"The Engine": What Is the Role of the Cerebellum in ADHD?

The cerebellum, which is located in the back of the skull, takes up only about 10% of brain volume, but contains more neurons than the rest of the brain. It facilitates fine motor control and is crucial for balance and gait. Neuroimaging studies have also found that the cerebellum works in concert with the frontal lobes during tasks that require attention, even if they do not require movement (Allen, Buxton, Wong, & Courchesne, 1997).

Magnetic Resonance Imaging (MRI) studies in three independent samples confirm that a portion of the cerebellum called the vermis (specifically the posterior-inferior vermis) is significantly smaller in children with ADHD (Berquin et al., 1998; Castellanos et al., in press; Mostofsky, Reiss, Lockhart, & Denckla, 1998). While differences in size do not prove that the posterior-inferior vermis is "abnormal," they implicate it in the ADHD neuronal circuit and suggest that this brain region may not be functioning optimally. It is noteworthy that the posterior-inferior vermis is nearly the only cerebellar region to receive rich dopaminergic inputs (Melchitzky & Lewis, 2000). These observations are consistent with the hypothesis that the function of the cerebellum is to improve the efficiency of executive function, which may in turn explain the inefficiency that is a hallmark of ADHD. Before turning to efficiency and executive function, we will discuss the neurochemical dopamine, which is also believed to be crucial to the neurobiology of ADHD.

"The Fuel": What Is the Role of Dopamine in ADHD?

The main dopamine circuit that regulates movement begins in a region of the mid-brain called the *substantia nigra*. The dopamine neurons that have their cell bodies in the substantia nigra send most of their dopamine to the *caudate nucleus* and *putamen*[4] in the basal ganglia. Too little dopamine in this circuit results in inactivity, such as in Parkinson's disease. Elevated levels of dopamine in this circuit are associated with high levels of physical activity, and in some cases, with uncontrolled movements, such as tics or other abnormal movements. Studies of cerebrospinal fluid (Castellanos et al., 1994; Castellanos et al., 1996b) provide tenuous evidence that hyperactive children may have "excessive" (for them and the specific situation) levels of dopamine in this circuit and that these are reversed by stimulants (Shetty & Chase, 1976). These lines of investigation have not led to conclusive findings because cerebrospinal fluid measures are too indirect, and because ethical and practical constraints make it impossible to obtain normal control samples.

As noted above, the principal means of inactivating dopamine in striatum is through the dopamine transporter, which "recycles" dopamine back into a dopamine neuron, where it is packaged for later release. Studies of mice who were created without a dopamine transporter have demonstrated that the dopamine transporter is a crucial regulator of dopamine function in the brain (Gainetdinov, Jones, & Caron, 1999; Giros, Jaber, Jones, Wightman, & Caron, 1996; Jones et al., 1998; Jones et al., 1999). Two studies of the dopamine transporter in adults with ADHD using single-photon emission computed tomography (SPECT) have found abnormally high concentrations of dopamine transporters in striatum (Dougherty et al., 1999; Krause,

[4] The nomenclature of the basal ganglia can be confusing. The caudate nucleus, putamen, and nucleus accumbens are collectively termed the *striatum* because these regions are striped in appearance. The putamen and globus pallidus are collectively termed the *lenticular nucleus* because of their lens-like shape. All of these regions consist of *ganglia*—or collections of neurons—and so are collectively described as the basal ganglia.

Dresel, Krause, Kung, and Tatsch, 2000). In the Krause et al. report (2000), none of the 10 patients with ADHD had ever been treated with stimulants before their first scan. Treatment with low-dose methylphenidate (Ritalin® 5 mg three times per day) for four weeks significantly reduced dopamine transporter concentrations. These studies suggest that dopamine is removed from striatal synapses too quickly (at least in adults with ADHD), and that methylphenidate and similar medicines improve its function by blocking many of the dopamine transporters. Since dopamine systems change continuously with increasing age, we cannot simply conclude that children with ADHD have the same abnormality.

The second major dopamine circuit in the brain resides in an area adjacent to the substantia nigra called the *ventral tegmental area (VTA).* VTA neurons send dopamine to the *limbic system,* which is the "emotional circuit" of the brain, and to all areas of the *frontal lobes,* which are associated with higher-level cognition, particularly with the psychological process termed *executive function.* Preliminary evidence indicates that adults with ADHD have deficient dopamine/norepinephrine function in the frontal lobes (Ernst et al., 1998), which may underlie the association of ADHD and impairments in executive function.

Trajectory: How Does Development Factor Into Our Understanding of ADHD?

Besides being a condition primarily diagnosed in childhood, there are several other important developmental aspects to ADHD. First is the notion that ADHD represents, at least in part, a "neurodevelopmental lag" (Kinsbourne, 1973). Children with ADHD trail about 2-3 years behind age-peers in social development (Dykens et al., 1990) and in cognitive tests of prefrontal brain functions (Amin, Douglas, Mendelson, & Dufresne, 1993; Chelune, Ferguson, Koon, & Dickey, 1986). While both groups of children progress at the same rate, the lag between them remains relatively constant. This developmental gap is much more striking during the school years than in early adulthood when individuals are more able to control his or her life circumstances (Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1998).

Because the neurodevelopmental gap remains fairly constant, rather than widening, the long-term prognosis for ADHD is relatively good, unless complications, such as drug and alcohol abuse, criminal activity, motor vehicle accidents (Cox, Merkel, Kovatchev, & Seward, 2000), or academic failure ensue. Extensive research has shown that individuals with ADHD are prone to these risks (Biederman et al., 1996a; Gittelman, Mannuzza, Shenker, & Bonagura, 1985; Hechtman, 1992; Klein & Mannuzza, 1991; Loeber, Green, Keenan, & Lahey, 1995; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Satterfield, Hoppe, & Schell, 1982; Verhulst, Eussen, Berden, Sanders-Woudstra, & vam der Ende, 1993), which makes early identification and effective treatment imperative.

Social and neurodevelopmental factors are not the only symptoms of ADHD that change over time. Locomotor hyperactivity, which is the most visible characteristic of ADHD in young children, eventually decreases with or without treatment (Frick et al., 1994; Hart, Lahey, Loeber, Appelgate, & Frick, 1995). By contrast, symptoms of inattention remain relatively constant (Hart et al., 1995) and become even more identifiable as academic workloads increase. Thus, many cases of Inattentive Type

ADHD are not identified until the middle grades or sometimes much later. The nature of the cognitive deficits in ADHD will be our next topic.

ADHD and Cognition: The Role of Executive Function

Despite the prominence of the term Attention-Deficit in ADHD, there are ample data that indicate ADHD is *not* characterized by a simple deficit of sustained attention (Sergeant, Oosterlaan, & Van der Meere, 1999), nor of selective or focused attention, divided attention, or even inhibition (Douglas, 1999; Sergeant, 2000). This does not mean, however, that children with ADHD do not have difficulty in those areas. Rather, their ability to exercise the various forms of attention varies greatly depending on how interested they are in an immediate stimulus.

A child's ability to become engrossed in television, a video game, or a book does not rule out the diagnosis of ADHD. In these situations, when a child displays rapt attention to a task, even to the point of being unable to disengage, it is understandable that many observers might conclude that such a child could not possibly have ADHD. It has been shown, however, that children with ADHD do not differ from controls in "automatic" tasks but differ significantly in tasks that require effort (Borcherding et al., 1988). Moreover, they become frustrated and discouraged more easily than controls under conditions of partial reinforcement compared to continuous reinforcement (Douglas & Parry, 1994; Wigal et al., 1998). Thus, tasks such as reading or playing video games, both of which can be relatively effortless and continuously reinforcing, are particularly ill suited to differentiate children who have ADHD from those who do not.

The psychological abilities that allow individuals to sustain their effort in such tasks as doing daily homework or test preparation are collectively termed *executive function*, the hallmarks of which are task analysis, strategy control, and strategy monitoring. These processes enable an individual to inhibit and delay responses, initiate and sustain activity, set priorities, and organize goal-oriented behaviors (Barkley, 1997b; Denckla, 1989; Denckla, 1996a).

Using the concept of executive function, or executive dysfunction, in ADHD seems to "fit" the symptoms that predominate in this population. Individuals with ADHD have difficulty sequencing, organizing, planning, and/or anticipating consequences of their actions. In essence, they act first, and think later. As has also been said, they know what to do, but they don't do it. The following quotations, taken from interviews conducted by the first author with gifted students who have ADHD, describe these difficulties.

Gabriel, age 18

- I get frustrated writing papers especially in English. I have a good grasp of the material and I know what I want to say but I just can't seem to focus my thoughts and put it on paper. I just go blank. I know that there is information and knowledge out there that I want to know but it is so hard for me to access it that it just gets to the point that it is not worth it sometimes. The frustration in trying to achieve it is not worth the end result.

Tina, age 15

- Kindergarten didn't go well for me. I never had time to finish assignments. I always wanted to go at my pace. I would get it perfect but it would take

forever. I was the same way in first and second and third grade. I would take my time but I would get stuff done. My first grade teacher summed it up perfectly. She said I was a plodder. In third grade, I think the ADD started showing a lot more. I remember we were doing this unit on outer space. One of the assignments was "list twenty facts about the sun." I had all this stuff in my head and I only got down eight of them. I got a B on the assignment. When I got it back I went up to my teacher and said "You know, I knew a lot more, I could have done a lot better." But I don't think she heard what I was saying because she thought I was this quiet, perfect little girl who basically got good grades. She said, "that's okay Tina, you're great." So I went home and told my mom "I had all this stuff in my head but I could only get out a fraction of it. She just didn't hear me."

- I remember being puzzled in third and fourth grade when I knew I was trying my best but I was getting out a hundredth of what I knew. But then I didn't know the reason why. I had friends who could turn out homework lickety-split and I would spend two and a half hours on things that should have gotten done in 45 minutes. But now I know that there's a reason and it's not because I'm not trying hard. It's great being able to say "This is why I could ***tell*** you a tale four hundred pages long but I could only write out four paragraphs of it."

Aaron, age 18

- In class, I have a whole bunch of thoughts about the material but they are not what anyone wants to talk about. It's a downward spiral because I can't quite get those thoughts out to people and then it's a further downward spiral because then I don't feel like doing any of the reading. I am very, very good, though, at keeping my head above water. I remember a lot of stuff—ridiculous amounts of stuff. I will see it once and it will be there.

- I'm pretty self-conscious about the way that the ADD comes out. Here are [sic] the way my thought patterns go. It sort of starts in the center and goes out from there like a cotton candy machine. It kind of jumps around the circle. People who have ADD get what I am talking about when I say that. If I'm stuck somewhere in the cotton candy machine and I think I have a good point, I have to tailor myself to make sure that it fits with the conversation. So in a way I have to stay one thought ahead of myself. The most frustrating times with a teacher are when I am trying to explain something and I know what I am talking about but they toss it out the window because it comes out goofy. Just give me another second and I know I will help the conversation somehow.

Summary of Part II

There is increasing evidence that prefrontal cortex, striatum, and cerebellum are subtly dysfunctional in ADHD. The dysfunction appears to be linked to dopamine, the key neuronal signal for attention and reward. At the psychological level, the deficits in ADHD are best described in terms of executive function, which encompasses the abilities to sequence and organize behaviors, anticipate consequences, and plan for the future.

In the next section, we will briefly present some conditions that are often associated with ADHD or that need to be excluded before a diagnosis of ADHD is made.

PART III. Comorbidity: What Is Not ADHD?

ADHD is a complex syndrome that often occurs in conjunction with other medical or psychological conditions, each of which would require its own monograph to discuss. It is because these comorbid conditions are so frequently associated with ADHD that comprehensive multidisciplinary assessments are important.

Learning Disabilities

Over one quarter of children with ADHD also have specific learning disabilities in reading, math, and written and/or spoken language (Semrud-Clikeman et al., 1992; Shaywitz & Shaywitz, 1991). Learning disabilities occur most frequently in children who have Inattentive Type ADHD (Gaub & Carlson, 1997a; Morgan, Hynd, Riccio, & Hall, 1996). Approximately 50% of students with learning disabilities have ADHD, which is frequently unrecognized and untreated (Bussing, Zima, Perwien, Belin, & Widawski, 1998; Denckla, 1996b; Pliszka, 1998).

Reading disabilities and ADHD are two distinct problems that can frequently co-occur, but do not overlap behaviorally (Halperin, Gittelman, Klein, & Rudel, 1984; Klorman et al., 1999; Shaywitz et al., 1995). One is not likely to be mistaken for the other. In addition, as neuroscience continues to probe the neurobiology of reading disabilities, it is clear from an anatomical perspective that the portions of the brain implicated in dyslexia have a distinct profile associated with difficulties in phonological processing and differ from those implicated in ADHD (Shaywitz et al., 1998).

Oppositional Defiant Disorder

The most common condition associated with ADHD is Oppositional Defiant Disorder (ODD), which is defined as "a pattern of negativistic, hostile, and defiant behavior lasting at least 6 months and consisting of at least 4 of the following behaviors: frequent loss of one's temper, frequent arguing with adults, frequent defiance of adults' requests or rules, frequent tendency to annoy others, frequent tendency to blame others for one's own misbehavior, tendency to be 'touchy' or easily annoyed by others, tendency to be frequently angry and resentful, and frequent spiteful or vindictive behavior" (American Psychiatric Association, 1994, pp. 93-94). ODD is found in about 40% of children who have ADHD and it predicts a worse prognosis than ADHD alone (Quay, 1999).

Conduct Disorder

Approximately 50% of children who meet criteria for ODD "progress" to Conduct Disorder in adolescence. The criteria for Conduct Disorder include aggression toward people and animals, deliberate destruction of property, deceitfulness or theft, and serious violations of rules (American Psychiatric Association, 1994). Although tentative, many researchers view Conduct Disorder as the malignant progression of inadequately treated Combined Type ADHD (Quay, 1999).

Substance Abuse and Dependence

Adolescents with ADHD are at high risk of alcohol abuse (Gittelman et al., 1985; Loney, 1988). They are also at high risk of developing Conduct Disorder, which in turn predicts high rates of drug abuse and dependence (Biederman et al., 1997). Any dramatic change in behavior, therefore, should raise questions of substance abuse, whether or not the adolescent has already been diagnosed with ADHD.

Tic Disorders

Motor tics are common in the elementary school years, by some estimates affecting 25% of children (Kurlan, 1994). In most cases, tics are mild and transient, although in some children they are chronic and may become severely impairing. Tics that are present for longer than one year, that include at least one vocal tic (e.g., throat clearing, sniffing, repeated phrases, rarely coprolalia), and more than one motor tic (blinking, twitching, etc.) are termed Tourette Disorder or Tourette's Syndrome. In the majority of Tourette cases that present for treatment, co-existing ADHD is also present, and in many of those cases, constitutes the primary problem (Abwender et al., 1996; Comings & Comings, 1990; Freeman, 1997).

Mood Disorders

Whether children with ADHD are at higher risk of developing depression and bipolar disorder (manic-depression) remains unresolved (Biederman et al., 1996b; Mannuzza et al., 1991; Pliszka, 1998). What is clear, however, is that symptoms of inattention, distractibility, and impulsivity can be associated with mood disorders. As with learning disabilities, these symptoms do not constitute a diagnosis of ADHD. For example, while mood disorders may exhibit cyclic patterns, the symptoms of ADHD do not fluctuate over periods of weeks or months (although they can fluctuate over minutes or hours). Moreover, mood disorders are only rarely diagnosed before age seven, whereas ADHD symptoms, by definition, must be impairing before age seven.

Anxiety Disorders

The main characteristic of all anxiety disorders (e.g., Separation Anxiety, phobias, Obsessive-Compulsive Disorder, Generalized Anxiety Disorder) is excessive worry, which can, like the disorders previously mentioned, affect attention and cause impulsivity. Similarly, Social Anxiety Disorder (also called Social Phobia) can produce marked restlessness and agitation, especially when the possibility of speaking in front of an audience (such as the classroom) presents itself. Obsessive-Compulsive Disorder, likewise, can produce symptoms of inattention because of the intrusive thoughts that characterize the syndrome. These disorders might therefore be confused with or associated with ADHD (Angold, Costello, & Erkanli, 1999).

Posttraumatic Stress Disorder

New onset of hyperactivity/impulsivity should raise the question of possible precipitating traumatic events. Posttraumatic Stress Disorder (PTSD) is associated

with ADHD, other anxiety disorders, and thoughts of suicide (Famularo, Fenton, Kinscherff, & Augustyn, 1996). Dramatic changes in behavior should always be explored, even if the diagnosis of ADHD has already been established.

Sleep Disorders

Studies of children with ADHD have found a greater than expected incidence of sleep problems in unmedicated children (Busby, Firestone, & Pivik, 1981; Dagan et al., 1997; Marcotte et al., 1998; Ramos Platon, Vela Bueno, Espinar Sierra, & Kales, 1990) as well as those taking stimulants (Bowen, Fenton, & Rappaport, 1991; Stein et al., 1996). At the same time, some researchers (Rogers, 1996; Tirosh, Sadeh, Munvez, & Lavie, 1993) have found the effects of Ritalin to be innocuous or even sleep inducing. Whatever the cause, however, inadequate sleep can impair a child's cognitive abilities (Dahl, 1996) and should be thoroughly investigated.

Summary of Part III

As evidenced by this brief review of the broad spectrum of conditions that mimic or accompany ADHD, the assessment and diagnosis of the disorder can be tricky. Consequently, to ensure reliability and validity, knowledgeable individuals in a multidisciplinary context should conduct the process. In the next section we will present some of the best-known methods to identify ADHD and later discuss the challenge of applying these to the gifted population.

PART IV. How Is ADHD Assessed and Diagnosed?

General Comments

Since there are no validated objective measures or tests for ADHD, teachers, parents, clinicians, and administrators must use their best judgment in evaluating a student. This can be difficult because the symptoms are variable and may change from situation to situation and from child to child. Moreover, as indicated by the previous discussion, other medical, behavioral, and psychological conditions may mimic attention deficits or may co-exist with them. Consequently, it is important for all significant persons in the child's environment to contribute thoughtfully to the assessment process.

The current criteria for ADHD, taken from the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV), the diagnostic "bible" of the American Psychiatric Association (1994), are presented in Appendix A. That these behavioral descriptions are inevitably subjective means that, even under research conditions, the repeated application of the criteria does not result in the same diagnoses 100% of the time. This was demonstrated when the DSM-IV criteria for ADHD were field-tested. Test-retest agreement for the 3 subtypes of ADHD was good, but not perfect (Lahey et al. 1994 ID: 3844). It is important to note these criteria, like all those included in DSM-IV, are provisional and like any single diagnostic assessment, have an appreciable chance (at least 20-25%) of being incorrect (Lahey et al., 1994).

While this level of inaccuracy is certainly undesirable, uncertainty has and always will accompany medical or psychological diagnoses. Just as every good general surgeon has operated on patients who later are discovered to have healthy appendices, clinicians will occasionally misdiagnose ADHD. Errors in diagnosis, however, are bi-directional. Thus while some children have been misdiagnosed and treated for ADHD that was not present (false positives), many others have ADHD or specific learning disabilities that have *not* been diagnosed (false negatives). For example, in a county-wide Tennessee sample, less than a third of children who were diagnosable with ADHD by teacher ratings had been so identified, and less than one quarter had been treated for the condition (Wolraich, Hannah, Baumgaertel, & Feurer, 1998).

Gender also appears to affect identification. Epidemiological studies confirm that while most children with ADHD are male, a substantial fraction (25-30%) is female (Lahey et al., 1999). Yet the proportion of children who are referred for evaluation and treatment remains 70-90% male (Gaub & Carlson, 1997b).

Types of ADHD

Four subtypes of Attention-Deficit/Hyperactivity Disorder are recognized in the DSM-IV (see Appendix A): Predominantly Hyperactive/Impulsive, Predominantly Inattentive, Combined, and Not Otherwise Specified (American Psychiatric Association, 1994). To meet the criteria for one of the specific subtypes, at least 6 of the 9 symptoms of hyperactivity/impulsivity, or at least 6 criteria from the 9 symptoms of inattention must be present. (Combined type means both sets of criteria are met.) The symptoms must occur *in more than one setting*, must persist

for *at least 6 months*, and must affect the individual "to a degree that is *maladaptive and inconsistent with developmental level*" (American Psychiatric Association, 1994, p. 83).

We have italicized parts of the previous sentence to emphasize that attention deficit disorder **cannot** and **should not** be diagnosed on the basis of a few fleeting observations. While there is much concern about clinicians possibly over-diagnosing ADHD, we are equally, if not more, disturbed by the casual use of the associated labels. Comments that describe a child's active behavior as "hyper" or episodic daydreaming as "attention deficit" only dissipate the meaning of the term and corrupt the identification process.

"It takes a village" to identify ADHD. That a child occasionally acts hyperactive at home or inattentive in the classroom is insufficient to warrant a formal diagnosis. The diagnostic label ADHD should only be applied when many factors are considered, over time, in multiple settings and then, only with deliberate care.

Impairment and Age-of-Onset

The diagnostic criteria for ADHD emphasize that "there must be clear evidence of *clinically significant impairment* in social, academic, or occupational functioning" (American Psychiatric Association, 1994, p. 84). Moreover, some impairing symptoms must be present before 7 years of age. As noted earlier, the age criterion distinguishes ADHD from other conditions, such as major depression, that typically emerge later in life. Several researchers (Applegate et al., 1997; Barkley & Biederman, 1997; Barkley & Biederman, 1998) have criticized the age criterion as being too limiting. Until this issue is resolved, however, the age criterion remains a requirement for the DSM-IV diagnosis of ADHD.

Diagnosis by Team

While the DSM-IV criteria can be used by anyone as a simple checklist, a diagnosis reached in this way has uncertain validity. Under optimal circumstances, a team, *including a qualified clinician*, such as a pediatrician, family physician, psychiatrist, neurologist, or psychologist should make the diagnosis of ADHD because only these types of specialists can assess the aforementioned physical and psychological problems that mimic ADHD. Information about these conditions is rarely available to school personnel, no matter how observant, experienced, or well trained.

Just as parents and teachers cannot diagnose ADHD on the basis of their observations alone, clinicians cannot function without information from parents and teachers. A recent study (Barbaresi & Olsen, 1998) revealed, however, that teachers receive only minimal information about ADHD in their undergraduate education. Therefore, until pre-service education programs offer more comprehensive training, school systems must assume responsibility for providing the relevant information. Opportunities to learn about such issues as identification, assessment, legal rights, classroom modifications and special education interventions should be offered to school personnel, parents, and the community at large to ensure the effectiveness and efficiency of assessment and diagnostic procedures.

The Teacher's Role in Assessment and Identification

The most hyperactive/impulsive children display their symptoms prior to reaching elementary school. For the majority of children with ADHD, however, symptoms only become clear-cut when their behavior can be observed regularly and compared to other children over a sustained period. The classroom teacher, therefore, is typically the best person to make such comparisons, especially when systematic behavioral checklists or rating scales are employed. When the child in question is gifted, an individual who specializes in giftedness should also be included in the process to provide information about the child's behavior in comparison to other children of similar abilities (Silverman, 1998).

Rating scales for ADHD can be classified into two major categories (Dykman, Ackerman, & Raney, 1993). One category, which includes such instruments as the Child Behavior Checklist (for parents) and the Teacher Report Form (Achenbach & Edelbrock, 1983), captures a wide range of behaviors and symptoms. These forms are used throughout the world in research studies and psychoeducational assessments. Their strengths include large normalization samples, and the requirement for open-ended observations about the child's strengths and the adult's areas of greatest concern; their weakness is that they were devised without reference to any particular diagnostic system. Their lack of correspondence with DSM-IV criteria means that they must be used in combination with diagnostically relevant rating scales.

The other type of rating scale typically focuses on a narrower range of behaviors or symptoms. The earliest of these was written by Conners (Goyette, Conners, & Ulrich, 1978), and its various versions have been widely used in research and clinical settings for over two decades. The most recent revisions have been re-normed and are now compatible with DSM-IV diagnostic criteria for ADHD (Conners, 1997). Other rating scales that are widely used to diagnose ADHD and to track treatment progress include the Attention Deficit Disorder Evaluation Scales (ADDES) (Bussing, Schuhmann, Belin, Widawski, & Perwien, 1998), the SKAMP (Wigal, Gupta, Guinta, & Swanson, 1998), the Behavior Assessment System for Children (BASC) (Vaughn, Riccio, Hynd, & Hall, 1997), and the Adolescent Behavior Checklist (Adams, Kelly, & McCarthy, 1997).

The NIMH Diagnostic Interview Schedule for Children-IV (DISC) is a comprehensive, computerized interview that branches its questions according to the subject's response (Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000). It is designed to identify psychiatric disorders such as Conduct Disorder, Oppositional Defiant Disorder, Tic Disorder, Generalized Anxiety Disorder, different forms of depression, and subtypes of ADHD. The main advantage of this sort of formal interview is its comprehensive coverage, which is why it has become essential for research studies. Another benefit is that the parent does not know what questions pertain to which diagnosis. Thus, the parent is "blind" to the questions that pertain to ADHD specifically. This diminishes the possibility that a "desired" diagnosis of ADHD will be obtained.

The DuPaul ADHD Rating Scale (DuPaul, Power, Anastopoulos, & Reid, 1998) is a symptom checklist comprised of the 18 DSM-IV diagnostic criteria for ADHD. Parents are asked to rate their child on performance and behavior while *off medication* using the Home version of the test. Teachers are asked to assess performance and behavior of the subject while *off medication* using the School

version of the test. Norms were gathered with sensitivity to sex (1043 girls, 930 boys, 27 unspecified), age (ages 4-20), and ethnic group inclusion (African American, Latino, Asian American, Native American, and Other, with percentages appropriate to representation in the population) based on a sample of 2000 participants.

Norms for Sub-populations

The most frequently used rating scales include separate age-related norms for males and females, since the population means differ for boys and girls (Gaub & Carlson, 1997b). Also, within the Conners normalization sample, teacher ratings of African Americans were higher than for comparison subjects (Epstein, March, Conners, & Jackson, 1998). Unfortunately, normalization samples among other sub-populations, including gifted students, are non-existent. Although rating scales have proven their utility, they are inherently subjective and minor differences in rating scales can lead to different results. Trained personnel, therefore, remain the crucial component in the evaluation process.

Summary of Part IV

There is widespread concern about the "overdiagnosis" of ADHD. However, when assessment involves experienced clinicians, working to integrate information from multiple sources, particularly from teachers, the end product can be remarkably reliable and valid. Such a comprehensive assessment requires sufficient time, and much of the current dissatisfaction may be traced to trends in health care that lead to a brief or even instant diagnosis. We believe that when such shortcuts are taken, the main problematic result is not generally the misdiagnosis of a "perfectly normal" child as having ADHD. Instead, what happens is that other comorbid problems, such as the ones discussed above, are missed and go untreated by clinicians and unremediated by educators.

Researchers continue to pursue objective tests for ADHD. New neuroimaging tools such as Positron Emission Tomography (PET) (Ernst et al., 1998; Zametkin et al., 1990), Single Photon Emission Computed Tomography (SPECT) (Lou, Andresen, Steinberg, McLaughlin, & Friberg, 1998), and Magnetic Resonance Imaging (MRI) (Castellanos et al., 1996a; Filipek et al., 1997; Vaidya et al., 1998) have been used in research studies with the goal of eventually providing new possibilities for assessment and evaluation. But even the most advanced and promising of these techniques (Cox et al., 1998; Dougherty et al., 1999; Krause et al., 2000; Monastra et al., 1999; Monastra, Lubar, & Linden, in press) is still not able to answer the question that is central to this monograph: *How can we objectively differentiate whether a child has ADHD when he or she is also gifted?*

PART V. ADHD or Gifted: Either or Both?

In recent years, several authors (Baum, Olenchak, & Owen, 1998; Cramond, 1995; Freed & Parsons, 1997; Lind, 1993; Tucker & Hafenstein, 1997; Webb & Latimer, 1993) have expressed concern that giftedness is often misconstrued as ADHD and that the diagnosis of ADHD among the gifted population has run amok. For example, the theory of excitabilities (Dabrowski & Piechowski, 1977) has been postulated as the basis for the misidentification of certain hyperactive behaviors in bright children (Baum et al., 1998; Freed & Parsons, 1997; Lind, 1993; Tucker & Hafenstein, 1997; Webb & Latimer, 1993). This theory postulates that children with high aptitude are more sensitive and perceptive than their peers with average aptitude. In essence, their experiences are intensified physically and emotionally. The theory defines five domains that may influence the behavior of a child with high-aptitude based on his or her excitabilities: psychomotor (rapid speech, impulsive actions), sensual (overindulgence, extrasensitive to environmental stimuli), intellectual (curious, intense), imaginational (melodramatic, mixes truth and fiction, use of image and metaphor), and emotional (extremes, somatic complaints, difficulty adjusting to new environments). It is argued that some of these qualities are likely to be interpreted as ADHD symptoms by parents or teachers who do not understand the nature of these overexcitabilities.

The theory of excitabilities is valuable as a framework for understanding emotional and cognitive development in gifted individuals. However, we believe that it does not capture the central concept of impairment, which is the absolute requirement for a psychiatric diagnosis such as ADHD.

We acknowledge for the purposes of this discussion that there are cases of mistaken diagnosis, although as of this writing, we have found ***no empirical data*** in the medical, educational, or psychological literature to substantiate the extent of this concern. It is worth noting that there *is* empirical evidence that there is no substantial over-diagnosis of ADHD among the general population (Goldman, Genel, Bezman, & Slanetz, 1998).

The lack of scientific data heightens our dismay over the wave of skepticism that appears to prevail about the existence of ADHD in gifted children. Specifically, we are concerned that the question "ADHD or gifted?" dismisses the possibility that the two conditions may coexist. Prudent attempts to avoid over-diagnosis must be balanced against a child's need for evaluation and treatment in the context of inevitable uncertainty when medical diagnoses are invoked.

In this context, Silverman (1998) notes that some professionals erroneously assume that a child who demonstrates sustained attention, such as a gifted child engaged in a high-interest activity, cannot have ADHD. It is understandable that an observer might discount the possibility of ADHD because from all appearances the child is so absorbed in a task that other stimuli fade into oblivion. While this state of rapt attention is often described as "flow"(Csikszentmihalyi, 1990), it can also be ascribed to "hyperfocus," which is a similar condition that individuals with ADHD frequently experience (Hallowell & Ratey, 1994a).

As we noted above, activities that are continuously reinforcing and "automatic," such as video or computer games or reading for pleasure, do not distinguish children who have ADHD from children who do not have ADHD, whereas effortful tasks do

(Borcherding et al., 1988; Douglas & Parry, 1994; Wigal et al., 1998). By virtue of their giftedness, the range of tasks that are perceived as "effortless" is broader for gifted children, which is why their ADHD may be less apparent than in children who struggle more obviously and to lesser effect.

Recent work (Kalbfleisch, 2000) suggests that the gifted child with ADHD is particularly predisposed to exhibit this state of "flow" or "hyperfocus." While this can be a positive aspect of task commitment and a sign of motivation, it becomes a problem when the child is asked to shift from one task to another. Therefore, while cognitively this state can have positive aspects, behaviorally it can also cause problems (Moon, Zentall, Grskovic, Hall, & Stormont, 2000). Furthermore, ADHD is not characterized by an *inability* to sustain attention, but rather by the inability to appropriately regulate the application of attention to tasks that are not intrinsically rewarding and/or that require effort. Such tasks are, sadly, characteristic of much of the work that is typically required in school, even in programs for gifted students.

To help the parent and teacher differentiate between giftedness and ADHD, Baum et al. (1998) suggest taking the following inventory of a child's environment before making a referral for ADHD.

- Observe and document under which circumstances the child has difficulty attending to tasks and otherwise performing acceptably and under which conditions learning becomes optimal.
- Consider Gardner's notion of multiple intelligences; are there adaptations of curricular presentations (e.g., visual or kinesthetic instead of verbal) that might capture the student's attention?
- Observe parent-child and teacher-child interactions to ascertain whether limits are set, if strategies for self-regulation are provided, and whether the student is able to self-regulate.
- Investigate whether or not the child's talents and gifts are being appropriately encouraged and supported through curriculum, instruction, and enrichment.
- Pretest the student to assess instructional levels and evaluate appropriate curricular pacing. (p. 102)

We agree that obtaining a comprehensive, multifaceted perspective on a child's everyday life is valuable. However, we are concerned about placing responsibility on educators for determining the existence and severity of problems such as self-regulation. Such issues need to be addressed in a comprehensive multidisciplinary manner as noted above.

While a misdiagnosis of ADHD is undesirable, diagnostic errors of omission are just as serious and may be even more prevalent among gifted students. This difficulty occurs when a student's over-reliance on strengths inadvertently obscures the disability. While emphasizing strengths may highlight a student's gifts and talents, it does not eliminate the reality of the condition and can, in fact, lead to a worse predicament in which the student distrusts his or her abilities because of the struggle to maintain them. On the other hand, if a student is allowed to acknowledge and experience the disability, he or she may learn appropriate compensatory or coping skills.

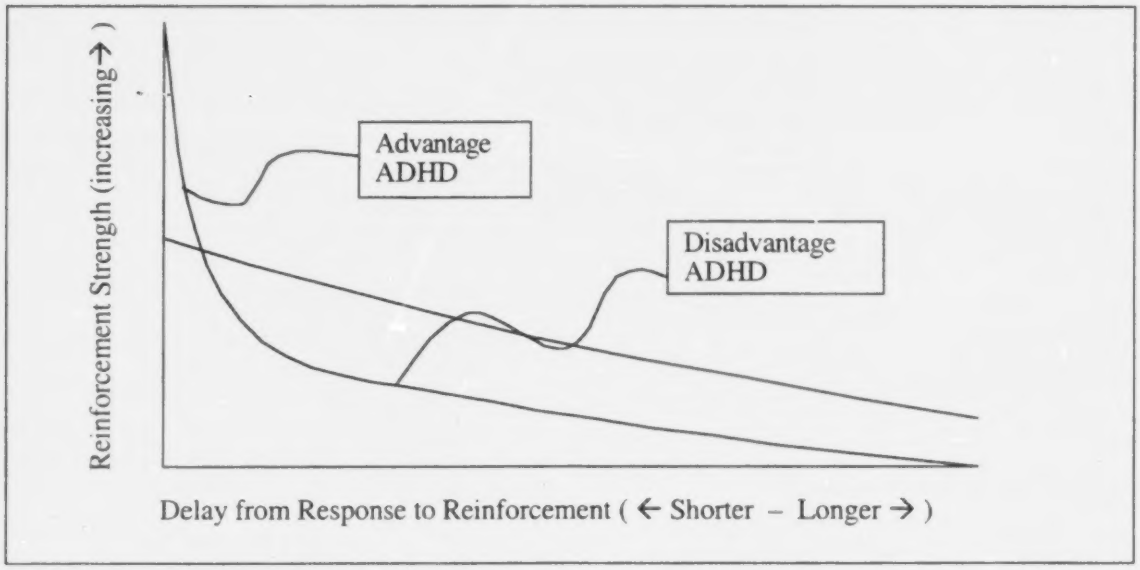
We believe that acknowledging that a child can be both gifted and have ADHD and that exploring the ways in which these conditions might interact in each child is a more productive way of looking at the problem than agonizing about a false dichotomy.

Theoretical Perspectives of ADHD and Giftedness: Behavioral, Cognitive, and Neurobiological

Behavioral Perspective

One of the fundamental laws of behavior is that the effectiveness of a reward or punishment (positive or negative reinforcer) decreases as the time interval between a behavior and its consequence increases. The rate at which reinforcement strength decreases is called the *reinforcement gradient.*

Sagvolden and colleagues (Sagvolden, Aase, Zeiner, & Berger, 1998; Sagvolden & Sergeant, 1998) have studied an animal model of hyperactivity, known as the *spontaneously hypertensive rat* (SHR) and observed that hyperactive rats and hyperactive children share one significant characteristic: they both exhibit steep reinforcement gradients. SHR rats exhibit difficulty in sustaining attention, a pattern of "impulsive" responding (repeated bursts of responses during extinction), and situational hyperactivity. The same pattern has been observed in children with ADHD who were tested in a similar paradigm to the one used with the SHR animals, as shown in the following figure:


Reinforcement Strength (increasing→)
Advantage ADHD
Disadvantage ADHD
Delay from Response to Reinforcement (← Shorter – Longer →)

The figure illustrates that the strength of a reinforcer is greatest when it immediately follows the reinforced behavior. It also shows that reinforcement strength decreases as the delay between behavior and reinforcer increases. This law of behavior is true for all individuals, whether they have ADHD or not. However, the drop-off appears to be much steeper for individuals with ADHD. Since most consequences are not immediate (the consequence of failing to study for a test may not be felt for weeks or months), their effects are substantially weaker in those who have ADHD. However, the studies by Sagvolden and colleagues have also detected an interesting exception to this rule of generalized impairment.

In those situations when the interval between response and consequence is very short (identified in the figure as the "Advantage ADHD" zone), reinforcement strength in ADHD individuals (and in rats that have a form of ADHD) is substantially greater than in controls. Thus, under deadline pressure, an ADHD individual can mobilize extraordinary motivation and "hyperfocus." If the task is challenging yet tractable, and if there are clear goals and rapid feedback, it is possible to experience the state of "flow," in which an individual is so intensely gratified by and absorbed in a task that attentional problems dissolve (Csikszentmihalyi, 1990).

Another behavioral perspective on ADHD is the relationship between ADHD, IQ, and divergent thinking. Shaw and Brown (1991) evaluated 97 sixth and seventh grade ADHD boys with IQs of 115 or above on a range of tests including cognitive abilities and verbal and figural aspects of problem solving. Their results were consistent throughout the group despite cultural differences. They found that boys with high-aptitude and ADHD used more diverse and nonverbal information during problem solving and that they scored higher on the Torrance Tests of Creative Thinking—Figural Forms (Torrance, 1990) than did boys with high-aptitude without ADHD.

In an unpublished study, Cramond (1990) examined the similarities between the behavioral manifestations of ADHD and divergent thinking and noted that higher creativity scores and the use of imagery are common descriptors of both individuals with ADHD and individuals who are creative. She compared 34 subjects with ADHD (ages 6-15) and 76 subjects (ages 13-15) from the Torrance Creative Scholars Program in Louisiana. The ADHD subjects performed close to the test mean on Figural Form A except in the area of elaboration. Elaboration requires the refining of an idea and attention to detail in contrast to generating many ideas. The emphasis is on quality, not quantity. On this portion of the scoring, subjects with ADHD performed more than one standard deviation above the test mean.

Cramond reported that 32% of the subjects with ADHD scored high enough to qualify for the Creative Scholars program. The creative group completed a checklist for symptoms of ADHD, and 26% of the group qualified for the diagnosis of ADHD with or without hyperactivity, though parents and teachers reported no elevated levels of impulsivity, hyperactivity, or inattentiveness in these adolescents. Cramond expressed the concern that creative children are misunderstood and, therefore, incorrectly diagnosed with an attention deficit and treated medically for a problem that they do not have. In a smaller study, Cramond (1994) described three ADHD boys who scored high on the Torrance Tests of Creative Thinking—Figural Forms test and acknowledged that ADHD and high creativity can co-exist.

Cognitive Perspective

Another way of describing the interaction between ADHD and giftedness may be found in Sternberg's early (1986) componential theory of intelligence, which proposes three kinds of components: knowledge-acquisition components (processes used in learning new material), metacomponents (higher-order processes used in planning, monitoring, and decision making), and performance components (processes used in executing a task).

For the purposes of this discussion, we have adapted this triarchy into the 3 stages of *input, processing*, and *output*. In this model, the *input stage* refers to the processes required for taking information in—listening, reading, kinesthetic

learning, etc. This stage corresponds to knowledge-acquisition. Learning disabilities, such as reading disorder (also called dyslexia), presumably have their greatest effects at this stage.

Processing refers to what happens "in the head" of the thinker and would be roughly analogous to some metacomponents. While definitions of intelligence are controversial, most theories acknowledge that gifted individuals have an exceptionally rich set of mental links within which to embed new knowledge. It is at this stage, then, that giftedness has its greatest impact.

While ADHD can influence the input and processing stages, the most pronounced effect of the symptoms typically occur in the *output* or performance stage (Sergeant et al., 1999). Until this stage, gifted/ADHD students may appear similar to other gifted students in terms of the amount of information they take in and process. Unlike other gifted students, however, they cannot summon their resources effectively and consistently at this stage.

Within the output stage, the most difficult mode of performance for the gifted/ADHD student is the linear channel of writing. While writing is challenging for many students, gifted/ADHD students experience more difficulty because of the gap between what they know and what they can express on paper. Oral communication, on the other hand, enables students with ADHD to reveal the extent of their knowledge through multiple channels such as tone of voice, facial expression, body and hand gestures, eye contact quality, and intensity. Oral presentations, therefore, are often superior to written work in determining a student's true level of mastery of the input and processing stages. In short, these students excel at process and struggle with product.

The assertion that ADHD is merely misdiagnosed giftedness is likely derived from observing a student during the input and processing stages. Therefore, when assessing and diagnosing ADHD in a student who is gifted, teachers should be careful to observe the quality and effectiveness of *all* stages of a student's learning and not draw premature conclusions.

Neurobiological Perspective

A recent pilot study by Kalbfleisch (2000) utilized quantitative electroencephalography (EEG) and a measure called the Consistency Index to examine the differences between males with and without ADHD, with either average or high aptitude while transitioning between reading a book and performing two subtests of the Torrance Tests for Creative Thinking—Figural Forms. The Consistency Index has been successful in distinguishing between males with and without ADHD (Cox et al., 1998; Merkel et al., 2000). In the Kalbfleisch study, preliminary results showed that gifted males with ADHD had the greatest difficulty shifting their attention from reading to the first divergent thinking task. In particular, they were more impaired than average-aptitude subjects with ADHD. When distinguishing between two subtypes of ADHD (Combined Type and Inattentive Type), the most impaired subjects were those with giftedness and Inattentive Type ADHD (commonly abbreviated as ADD).

This difficulty in shifting attention may be related to "hyperfocus," which may become an advantage if an individual is highly interested or motivated. On the other hand, difficulty in shifting attention results in resistance to changes in routine, schedule, or environment and often leads to angry, oppositional behavior. A

comparative case study (Moon et al., 2000) found that gifted boys with ADHD experienced more behavior and emotional adjustment problems that impacted their relationships with family, school, and peers when compared to their peers with ADHD only or giftedness without ADHD.

Given the realities of the co-existence of giftedness and ADHD, the question should not be "ADHD or gifted?" but rather "how impaired is this student by his/her ADHD?" Some children are able to compensate in most situations for their ADHD (and neither they nor their parents or teachers may be aware of it); others are seriously handicapped. The single most relevant element that must be considered in evaluating ADHD is the degree of *impairment* a child experiences as a result of the behaviors.

A child whose behavior causes him/her to be impaired academically, socially, or in the development of a sense of self, should be examined from a clinical/medical perspective to exclude potentially treatable conditions, even if the behavior may be similar to the traits typically ascribed to creativity or giftedness (Cramond, 1995) or to "overexcitabilities" (Piechowski, 1997; Silverman, 1993). However, this does not mean that every child who is impaired needs medication. As many authors have noted (Diller, 1998; Flick, 1998; Hartmann, 1993; Lerner, Lowenthal, & Lerner, 1995), non-medical interventions can be used within the school and home and should be tried before more intrusive interventions are employed.

Summary of Part V

A careful reading of the current literature on the question of giftedness and ADHD reveals few facts and much concern about the potential misdiagnosis of creative, gifted children as ADHD. There has been much less concern about missing the diagnosis of ADHD in gifted children, which we contend is also a problem that should be confronted.

In this section, we have also described some circumstances in which gifted individuals with ADHD may be at an advantage. One of these is the state of "flow" which is sometimes also called "hyperfocus." It is in this state that the breadth of options and perspectives known as giftedness can interact with ADHD to produce unpredictable yet delightful results. These moments of apparent alchemy often raise doubts about the validity of the diagnosis of ADHD because the students appears to perform with ease at such a high level. We contend that, on the contrary, such flashes of achievement must be measured against the overall pattern of disappointment and underachievement that all too frequently accompany even highly gifted students who have undiagnosed ADHD.

PART VI. What Are the Treatments for ADHD?

Kevin, age 16

- When I began high school, I began seeing signs of my failure to produce the same results as my previous years. My tactics that had never failed me waned. I couldn't break the cycle of no effort. My ADHD got the best of me and took more time than I could allow for acceptable work. I got a very overwhelming sense of not being up to par. Other students who I never considered extremely bright could do more and better work than I. I knew it wasn't intellect. Things that clicked the first time I heard them in class would take these other students days to comprehend. I thought my gift could pull me through like it always had: ahead of the crowd and a prime student example. I was gravely mistaken.

Michael, age 18

- Patience from tutors, from teachers, from parents, from anyone is so important, especially with older students. It's easy when you are sitting with a kindergartner because they look so cute when they have trouble reading. But it's a different story when you have an eleventh grader sitting there crying every night because he doesn't know whether he can handle his classes or get the grades he wants.

Studies of the natural course of ADHD have shown that approximately three-quarters of average-ability individuals who are diagnosed in childhood will go on to lead productive lives (Hechtman, 1992; Mannuzza et al., 1993). However, these studies also document that about one-half of children who are diagnosed with ADHD develop serious problems with illegal drugs, alcohol, and criminal behavior during adolescence, and that half of this group (25% of the initial samples) continue these behaviors and addictions into adulthood (Hechtman, Weiss, & Perlman, 1984; Mannuzza, Klein, Konig, & Giampino, 1989).

The goal of treatment is to prevent such negative outcomes. A typical treatment plan for children with ADHD should include counseling, behavior management, educational modifications and, in cases where these do not suffice, medication. For the purposes of this monograph, however, we will limit our discussion to those issues that are most relevant to education and to gifted students in particular. Many of the general references in the bibliography and appendices provide excellent information for those seeking further information (Diller, 1998; Flick, 1998; Hallowell & Ratey, 1994b; Hartmann, 1993; Lerner, Lowenthal, & Lerner, 1995; Wiggins, 1998).

Educational Strategies for Gifted Students With ADHD

While empirical investigations on the causes and effects of ADHD abound, few focus on regular (e.g., non-clinical) classroom approaches to treatment. This does not mean, however, that there is a lack of practical wisdom from the field. In fact, there appears to be a good deal of consistency in authors' recommendations for educational interventions for the regular classroom; several excellent resources for strategies (e.g., classroom organization, curriculum modification, behavior management, listening and memory techniques, social skills training and time management) are listed in Appendix C. These, like other educational strategies, must be tailored to the student's abilities and specific deficits.

Gabriel, age 18

- The worst teacher I ever had never listened. She didn't understand that even though my head was on the table, I was still listening. It is actually easier for me to close my eyes and listen because I don't have as many outside distractions. Sometimes I need to stand up and walk around the room. It's different for everybody. Each of my friends who has ADHD has a different way of coping with it. They walk around, go about, watch TV, listen to music, anything that doesn't take complete absorption in what they are doing. It's really easy to do multiple things at once. But when you try to focus completely on one thing, you get more prone to distraction.

Tina, age 15

- Extended time is great—without it I'd be sunk. The use of the computer is incredibly beneficial. Shortened questions are good. Buddy paper notes—where another student uses carbon paper for notes and gives you the bottom copy—are nice. But I also like taking my own notes because then I can write down stuff that maybe is not on the overhead but I know I'd forget. It also allows me to doodle and keep my hands busy while my mind is on the task. What teachers need to do is make sure the work is at the intellectual level of the student and THEN make accommodations. Like maybe instead of that ten-page term paper, have the student do it verbally, maybe in front of the class, or into a tape recorder. Or maybe the student would work better doing it in pictures. Don't do it the other way around.

Rachel, age 16

- My best teacher would spend extra time working on my essays with me. If I handed it in before it was due, she would correct it and give it back to me and if I got a C or below she would let me re-write it and average the grades. In my school, we can get up and walk around if we need to and we can sit on the floor, which I love, because I have trouble sitting still in a seat. So when I am on the floor I can lay down if I need to. I am a lot less embarrassed now because my current school is a lot more accepting.

Kevin, age 16

- Goals have always been too much stress for me, and I don't recommend them unless they work for the individual who chooses to use them. Let the child work at his or her own pace. Always support them.

The primary criteria for educational programs for students with ADHD are structure, stimulation, and individualization (Flick, 1998; Lerner et al., 1995). While these qualities are similar to those that found in programs for gifted students (VanTassel-Baska, 1997), this does not mean that placement in a gifted program precludes the student's need for further accommodations.

In a program that stresses gifts, talents, and creativity (Renzulli & Reis, 1997), the student's need for additional assistance may be inadvertently camouflaged. An optimal program for gifted students with ADHD, therefore, should both nurture the gifts with *complexity* and *challenge* and accommodate the ADHD with *support* and *structure*.

How might educators create a system to address these dimensions? Table 1 provides some examples of how common instructional practices from the lexicon of gifted child education might be adapted to address the student's need for high level learning while integrating principles of modification for ADHD. The strategies listed in column 1 are representative of those frequently recommended for students with ADHD; column 2 specifies techniques and activities commonly used in gifted child education. Column 3 suggests ways in which the two might be combined to effectively teach gifted children with ADHD.

Table1.

Instructional Strategies for Gifted Students With ADHD

Standard Modification for Student With ADHD	**Standard Instructional Strategy From Gifted Child Education**	**Modified Instructional Strategy for Gifted Students With ADHD**
To increase sustained attention, break complicated tasks into smaller parts to be completed at different times.	Synectics (Gordon, 1960; Gordon, 1974; Gordon & Poze, 1972)	Present and practice Synectics stages in isolation rather than teach the entire process at one time.
To improve listening ability, use visual aides to augment oral presentation.	Creative Problem Solving (CPS) (Eberle & Stanish, 1985; Isaksen & Dorval, 1996; Isaksen & Treffinger, 1985; Isaksen, Treffinger, & Dorval, 1997; Treffinger, 1995); Future Problem Solving (FPS) (Torrance & Sisk, 1997)	Write the rules and vocabulary of CPS/FPS on a poster or cue cards and refer to them often rather than rely solely on verbal instructions.
To minimize distractions, announce transitions in advance of their occurrence.	CPS/FPS, Synectics	Announce each stage of the process before moving to the next.
To promote performance, use a buddy system in which students assist each other in concluding the day's work and reviewing the requirements for the next day.	Enrichment Clusters (Renzulli, 1994; Renzulli & Reis, 1997)	Assign buddies within each enrichment cluster, as well as in the student's regular classroom.
To cultivate organizational skills, provide a schedule so that the student knows exactly what to do for each class period.	Curriculum Compacting (Reis, Burns, & Renzulli, 1993; Renzulli, 1994)	Create and identify daily compacting procedures in addition to or instead of longer term goals.
To encourage performance, promote the use of tape recorders, computers, word processor, and other technological devices	Mentorships (Clasen & Clasen, 1997; Noller & Frey, 1994; Reilly, 1992)	Employ alternative types of mentorships (e.g., on-line, correspondence, video) rather than rely exclusively on in-person relationships.
To improve listening ability, eliminate extraneous noise and visual stimulation whenever possible.	Independent study (Betts, 1991; Betts & Kercher, 1999; Kaplan & Gould, 1995; Schlichter, 1997)	Create a quiet area for student-teacher conferences rather than hold meetings at the teacher's desk or in other high traffic areas.
To promote socialization, teach students effective communication skills that will generalize to a variety of situations.	Type III activities (Reis et al., 1993; Renzulli, 1994)	Encourage students to present their work to a variety of audiences rather than limit themselves to one type of audience.
To develop pro-social behavior, create a list of positive behaviors and coping strategies.	Bibliotherapy (Frasier & McCannon, 1999; Schlichter, 1997)	When presenting biographies of eminent persons and fictitious gifted characters, focus on learning and problem solving rather than success alone and find, when possible, models of people who have triumphed over disabilities.
To encourage persistence, help students identify environmental distracters.	Guided fantasy (Eberle, 1996; Torrance & Safter, 1999)	Guide students through a perfect day fantasy, allowing them to identify those factors that interrupt their focus and interfere with the achievement of their goals.
To help students understand the consequences of their behavior, use appropriate reinforcers.	Interest inventories (Renzulli, 1994)	Allow students to select challenging, high-interest rewards such as reading or puzzles as well as standard reinforcers such as food or stickers.

While Table 1 provides a way of thinking about the problem, it cannot be construed as a curriculum or program for gifted students with ADHD; to date, we have found no model designed exclusively for this purpose. Of the many models currently available in the educational marketplace, we believe that those emphasizing diverse types of learning and production (Gardner, 1991; Kaplan & Gould, 1995; Renzulli, 1994; Sternberg, Ferrari, Clinkenbeard, & Grigorenko, 1996) are the most promising for gifted students with ADHD because they acknowledge and support many ways in which students can be productive and successful.

Although classroom modifications are important, the most pressing component of an educational treatment plan for gifted students with ADHD is educators' attitudes toward them. This means that educators and students alike must learn about the dimensions of giftedness (Colangelo, 1997; Galbraith & Delisle, 1996) and ADHD (Baum, Olenchak, & Owen, 1998; Moon, Zentall, Grskovic, Hall, & Stormont, in press). Educators should also be willing to suspend traditional evaluation techniques and offer multi-modal assessment tasks that portray a child's true range of abilities and interests (Renzulli, 1994; Wiggins, 1998). Finally, educators must construct definitions of success that reflect process and diversity as well as conventional standards of achievement (Flick, 1998; Tomlinson, Callahan, & Lelli, 1997).

We wish to emphasize, however, that even in the best educational environment, with the most informed and flexible teacher, most students who have ADHD, including gifted students, still need other types of help. While non-medical interventions have their strong proponents, (Flick, 1998; Lerner et al., 1995), medication, with all its controversy, remains the most well-researched and commonly recommended mode of treatment.

Medications

Michael, age 18

- What has helped me overcome these obstacles? Medicine is number one. I took Ritalin for many years and am now taking Dexedrine. Those were the key factors.

Kevin, age 16

- Until I got the medicine, things were looking downhill. I first tried Ritalin [SR] supposedly for all day/long term. This resulted in an unforeseen disaster. It was the end of my freshman year and I began noticing when it would wear off. The last hour of the day seemed interminable and I began to have extremely bad mood spells. I came up with the theory that it was not the medicine giving me adverse effects, but rather my brain noticing it wearing off. I shared this idea with my psychiatrist. He now agrees that my interpretation is probably correct. We decided to switch to the 4-hour Dexedrine. I am very grateful that we found it.

Gabriel, age 18

- When I'm on Ritalin I work more like a normal person. I can focus without stressing so hard and concepts seem to sink in easier. When I am having problems with them I can spend enough time concentrating on that one thing alone without having my mind wander.

Controversies over the use of psychotropic medication in children abound in the popular press. One frequent concern is that children may become addicted to the medicine or stigmatized by taking it (Armstrong, 1995). A second concern is that medicine simply masks the problem and therefore interferes with the student's learning how to cope "in the real world" (Hartmann, 1993). Another is that

medicine is over-prescribed to control children who have failed to comply with adult expectations (Diller, 1998). While there are always individual cases that can be made for each of these points, much of the underlying concern is based on anecdote, hearsay, and misinformation rather than scientific evidence.

In this section we will not attempt to reconcile the entire issue of medicine and children because the issue is so variable and emotionally laden. Moreover, the needs of individual children are so different that generalizations about medicine would be meaningless and inappropriate. Instead we will briefly present some basic information about the medicines currently used to treat attention deficit disorder and list some possible benefits and side effects that might occur.

Psychostimulants such as methylphenidate (brand names Ritalin®, Metadate®, Methyllin®, Concerta®), dextroamphetamine (Dexedrine®), amphetamine mixtures (Adderall®), and pemoline (Cylert®) have been researched extensively and repeatedly found in controlled studies to be safe and effective (Swanson et al., 1993). These drugs, which act by increasing the amount of one or both of the neurotransmitters dopamine and norepinephrine, have significant short-term benefits in about 70% to 80% of children who have ADHD (Spencer et al., 1996), with a somewhat lower positive response rate in children who have ADD without hyperactivity. The benefits of these medicines include a reduction of the core symptoms of inattention, impulsivity, and hyperactivity, as well as some improvements in motor, social, emotional, and executive functioning.

When these symptoms are reduced or eliminated, other benefits such as improved classroom learning and productivity (Balthazor, Wagner, & Pelham, Jr., 1991; Douglas, Barr, Amin, O'Neill, & Britton, 1988), improved short term memory (Swanson, Kinsbourne, Roberts, & Zucker, 1978), improved interactions with parents, teachers, and peers (Barkley, Karlsson, Strzelecki, & Murphy, 1984; Pelham, Bender, Caddell, Booth, & Morrer, 1985), and improved perceptual efficiency (Rapport, DuPaul, Stoner, & Jones, 1986) also occur. Although stimulants can produce mild to moderate side effects, such as appetite suppression, headaches, irritability, trouble falling asleep (and motor or vocal tics in some susceptible children), these usually subside when the prescribing physician changes the timing, dosage, or formulation of the drug (Miller & Castellanos, 1998). For most children, however, the benefits of improved functioning in school, at home, and with peers outweigh the temporary discomfort of side effects.

One of the most dramatic developments during the 1990's has been the increase in the prescription of stimulant medications, particularly in the U.S. Studies of trends in prescription patterns have found that the increased production and prescription of stimulants is largely explained by treatment of previously neglected groups, such as girls and children with predominantly inattentive ADHD (Goldman et al., 1998). Furthermore, treatment with medications is being extended longer into adolescence and young adulthood, and treatment is more likely to be administered daily and year round, instead of just during school hours (Safer & Krager, 1994).

At the same time, we acknowledge that there continue to be wide regional variations in stimulant treatment. For example, in southeastern Virginia, up to 20% of White fifth grade boys were being treated with medication for ADHD (LeFever, Dawson, & Morrow, 1999). On the other hand, another epidemiological study in four communities found that only 12% of children meeting criteria for ADHD had been treated with stimulants during the prior year (Jensen et al., 1999).

While the long-term effects of stimulants appear to be relatively benign, there are no definitive answers regarding long-term safety and one longitudinal study raised the possibility that use of stimulant medication in childhood may be associated with a later increased risk of smoking and stimulant abuse beyond that expected from ADHD alone (Lambert & Hartsough, 1998). By contrast, two other longitudinal studies found that treatment with stimulants decreased the long-term risk of drug abuse (Biederman, Wilens, Mick, Spencer, & Faraone, 1999). Regardless, stimulant medication should be used judiciously and should be reserved for those children who are significantly impaired and for whom psychosocial and behavioral programs and significant academic accommodations have not provided adequate benefit.

Is ADHD Included in Special Education Laws?

The 1999 reauthorization of the Individuals with Disabilities Education Act explicitly recognized, for the first time, ADHD (and ADD) as disorders that should be classified as Other Health Impaired, when they adversely affect a child's educational performance. The reader is referred to http://www.chadd.org/legislative/govt.htm for further detailed information and relevant hyperlinks.

Children who have attention deficit disorders but who do not require special education services may still qualify for appropriate accommodations within standard educational settings under The Americans with Disabilities Act (1990), which protects individuals in the workplace, post-secondary institutions, and secular private schools or Section 504 of the Rehabilitation Act of 1973, which prohibits discrimination against people who have disabilities.

ADHD and Giftedness: Where Do We Go From Here?

Clearly, this monograph must conclude with a plea for additional empirical research on giftedness and attention deficit disorders. Questions such as incidence of DSM-IV subtypes of ADHD among the gifted population must be investigated before other types of research can proceed. If such research were to show that current DSM-IV criteria identify significantly different proportions of gifted students compared to the general population (over or under diagnosis), subsequent studies would be able to explore the sources and characteristics of the discrepancies. The availability of data would in turn facilitate and encourage the development of strategies for appropriate identification and curriculum.

The information in this monograph is not intended to implicate ADHD as a defect that must be "cured." In fact, our experience of many gifted children with ADHD resonates with our colleagues' perceptions that the condition can not only inhibit, but enhance the realization of gifts and talents.

Educators of gifted students with ADHD face a formidable task in that they must provide opportunities for students to apply their strengths while ameliorating their deficits. Although the same might be said of any sound educational program, this is more daunting for gifted students with ADHD because of the striking disparities these conditions can create. Only through consistent attention, immeasurable creativity, and enduring patience by educators, parents, and students, coupled with substantive research, can these challenges be adequately addressed.

Recommendations for Parents and Educators

Recommendation 1: Be aware that ADHD and giftedness can co-exist.
Comments: Because there is currently only limited research evidence about gifted students with ADHD, you will have to learn as much as you can about both conditions and apply the information to the individual child. Do not prematurely rule out either possibility based on insufficient information.

Recommendation 2: Explore multiple perspectives in your pursuit of information about ADHD.
Comments: Medical, psychological, and educational databases all provide valuable information and viewpoints. Be aware of subtle prejudices and archaic beliefs (e.g., "very few girls have ADHD," "a child who can sustain attention can't have ADHD").

Recommendation 3: Remember that the most important criterion for diagnosing ADHD is the degree of impairment experienced by the child in two or more settings.
Comments: Do not assume that a high achieving student does not experience impairment. All aspects of a student's life—home, school, social groups, extra-curricular activities, must be considered.

Recommendation 4: Utilize a multidisciplinary team to arrive at diagnoses and to develop comprehensive treatment plans.
Comments: Gather as much information as possible about the child, *including early childhood behavior*. Information should be obtained from multiple observers from a variety of settings. Seek professionals who are knowledgeable about giftedness and ADHD or are at least open to learning about both conditions.

Recommendation 5: Become familiar with a variety of educational and behavioral strategies to determine which combinations might be effective for the individual child.
Comments: ADHD and giftedness are both complex "conditions"; combined, they are even more so. No list of strategies, therefore, can be 100% right for a particular child. Parents and educators must work together to provide creative solutions to the challenges presented by the gifted child with ADHD.

Recommendation 6: Be cautious about promises of "quick-fixes"—whether behavioral, educational, or medical.
Comments: Remember that effective solutions to a problem take time to work. Don't look to any treatment as the "cure" for ADHD or the "magic bullet" that will facilitate a child's giftedness. If, after a reasonable length of time, you observe that the intervention does not work, keep searching until you find one that does.

Recommendation 7: Be aware that individuals with ADHD have their greatest difficulties in the "output" stage of cognitive processing.
Comments: When possible, include oral presentations as a means of assessing performance or mastery of a content area, rather than relying only on a written product.

Recommendation 8: Determine whether shifting attention is a point of vulnerability for the student.
Comment: Many angry confrontations are rooted in frustration over this difficulty in shifting from one cognitive task to another. Look for natural "breaks" in the task, and/or provide tactful advance reminders.

Recommendation 9: Model and support the process of "knowing thyself."
Comment: Successful maturation requires learning and appreciating one's natural strengths as well as weaknesses. Seek to remediate weaknesses in the context of building and capitalizing on the child's strengths. Teach the child that everyone has weaknesses.

Recommendation 10: Advocate for and support systematic research into ADHD within the gifted population.
Comment: Research programs require contributions from academics and funding agencies, but they cannot succeed without support and interest from the wider community.

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Appendix A

Diagnostic Criteria for Attention-Deficit/Hyperactivity Disorder

Diagnostic Criteria for Attention-Deficit/Hyperactivity Disorder

A. Either (1) or (2):

(1) six (or more) of the following symptoms of inattention have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

Inattention

(a) often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
(b) often has difficulty sustaining attention in tasks or play activities
(c) often does not seem to listen when spoken to directly
(d) often does not follow through on instructions and fails to finish schoolwork, chores, duties in the workplace (not due to oppositional behavior or failure to understand instructions)
(e) often has difficulty organizing tasks and activities
(f) often avoids, dislikes or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
(g) often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books or tools)
(h) is often easily distracted by external stimuli
(i) is often forgetful in daily activities

(2) six (or more) of the following symptoms of hyperactivity-impulsivity have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level

Hyperactivity

(a) often fidgets with hands or feet or squirms in seat
(b) often leaves seat in classroom or in other situations in which remaining seated is expected
(c) often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
(d) often has difficulty playing or engaging in leisure activities quietly
(e) is often "on the go" or often acts as if "driven by a motor"
(f) often talks excessively

Impulsivity

(g) often blurts out answers before questions have been completed
(h) often has difficulty awaiting turn
(i) often interrupts or intrudes on others (e.g., butts into conversations or games)

B. Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

C. Some impairment from the symptoms is present in two or more settings (e.g., at school [or work] and at home).

D. There must be clear evidence of clinically significant impairment in social, academic or occupational functioning.

E. The symptoms do not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and are not better accounted for by another mental disorder (e.g., Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Code based on type:

314.01 – Attention-Deficit/Hyperactivity Disorder, Combined Type: if both Criteria Al and A2 are met for the past 6 months

314.00 – Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type: if Criterion Al is met but Criterion A2 is not met for the past 6 months

314.01 – Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-impulsive Type: if Criterion A2 is met but Criterion Al is not met for the past 6 months

Appendix B

Glossary of Terms: A User's Guide to the Brain

Glossary of Terms: A User's Guide to the Brain

Basal ganglia: Collections of gray matter located below the cerebral hemispheres, the basal ganglia consist of the *caudate nucleus*, the *putamen*, and the *globus pallidus*. Another associated region is the subthalamic nucleus. The primary inputs to the basal ganglia are from cortex, and the primary outputs are to thalamus.

Caudate nucleus and *putamen*: Sometimes lumped together into the single term *striatum*, these two nuclei are where cortical inputs from pyramidal neurons are received. The cells within these nuclei contain GABA (see below).

Cerebellum: Literally the little brain, the cerebellum is about 10% of the size of the total brain, but it contains more neurons than the rest of the brain. Known to be important for motor coordination, the supportive role of the cerebellum in cognition has only been recently appreciated thanks to brain imaging studies.

Cortex: Abbreviation for cerebral cortex, the outer layer of gray matter covering the cerebral hemispheres. The cortex consists of numerous *cortical columns*, each of which has 6 layers. Each column functions as an independent unit, with connections to many other columns, some nearby and others in distant regions. The primary output neurons of cortical columns are shaped like pyramids, and hence are called *pyramidal neurons*. Pyramidal neurons release glutamate from their axons. Within each cortical column, numerous inhibitory interneurons release GABA.

Dopamine: Modulatory neurotransmitter manufactured by a small number of cells in the middle of the brain (midbrain). Dopamine produced in the *substantia nigra* (called black substance because it is much darker than other brain regions) is required for the initiation of movement. Dopamine produced in the *ventral tegmental area (VTA)* alerts other brain regions to important future events.

Dopamine Receptors: There are two main groups of dopamine receptors in the brain and a total of five different subtypes, D1 – D5. The net effect of dopamine depends in part on the type of receptor activated. For example, D1 (and D5) receptors are generally excitatory, whereas D2 (as well as D3 and D4) receptors are generally inhibitory. One variation (allele) of the dopamine 4 receptor (DRD4) has been found to be associated with an increased risk of ADHD in several studies.

Dopamine Transporter: The dopamine transporter (DAT1) is the molecule that deactivates dopamine after it has been released from a neuron by transporting it back into the neuron. Methylphenidate (Ritalin) decreases its effectiveness, and thus increases the effects of dopamine.

GABA: Abbreviation for gamma-amino-butyric acid, the major inhibitory neurotransmitter.

Globus pallidus: Though this small region has a single name, it is subdivided into two regions, an internal portion, and an external portion. The external portion (abbreviated GP_e) is a crucial link in the inhibitory *indirect pathway*.

The internal portion (GP_i) provides the primary output from the basal ganglia to the thalamus.

Glutamate: The major excitatory neurotransmitter, glutamate is released by the main cortical cells and by cells in the thalamus and sub-thalamic nucleus.

Gray matter: Collections of neuronal cell bodies, where incoming signals are processed.

Human Genome Project: The international effort to spell out each and every one of the 3.3 billion letters that compose human DNA. The working draft of the human genome announced in March 2000 is estimated to be 90% complete. The final version is expected by 2003. This effort has the potential to revolutionize biology by providing a complete listing and locations for all human genes. A major unsettled question is how many human genes there are. Estimates range from 30,000 to 150,000. Understanding their interactions will be the principal task of medicine and biology in the 21st century.

Neuromodulators: Chemicals that are released by neurons (e.g., dopamine, norepinephrine, serotonin) that have relatively slow and long-lasting effects on the responses of other neurons.

Neurotransmitters: Chemicals that are released by neurons to activate or inhibit other neurons. Some are only effective for a few milliseconds, others have longer and slower modulatory effects, setting the "mood music" for particular brain circuits.

Neuron: A nerve cell, the structural and functional unit of the nervous system. All neurons consist of a cell body (soma) where the cell's DNA is stored, and at least one axon, and many dendrites.

Norepinephrine: Neurotransmitter released by small number of cells in the *locus coeruleus* (literally, blue place) that communicates with the entire cerebral cortex. This is the primary alerting signal for the brain, and crucial for fight-or-flight responses. Norepinephrine is critical for sustained attention, also termed vigilance.

Prefrontal Cortex (PFC): The portion of the cortex found right behind the forehead. The most developed part of the brain in humans compared to other animals, PFC has been compared to the conductor of the cerebral orchestra. PFC coordinates the functions of other cortical regions, such as those that exclusively process sensory information or those that generate motor signals.

Receptors: Protein molecules that are found on the outer surfaces of neurons. They function like molecular locks activated by specific neurotransmitters. There are generally many different types of receptor for any given neurotransmitter.

Synapse: The place where an axon meets a dendrite; an impulse traveling along the axon in the first neuron releases chemicals (neurotransmitters) when it reaches the synapse which "unlocks" impulses in the second neuron. The net result may be increased or decreased activity in the second neuron (excitation or inhibition, respectively).

Thalamus: The part of the brain that receives inputs from all the senses except for the sense of smell; this sensory information is associated, synthesized, and then relayed to specific areas of the brain. Impulses are also received from various parts of the brain and then relayed to nerve pathways leading to contraction of muscles.

White matter: Bundles of axons especially wrapped to connect neurons across long distances.

Appendix C

User-Friendly References and Resources About ADHD

User-Friendly References and Resources About ADHD

Books

The following books are outstanding for their readability, accuracy, practicality, and scope.

Readings for Professionals and Parents

Barkley, R. A. (1990). *Attention deficit hyperactivity disorder: A handbook for diagnosis and treatment.* New York: Guilford Press.

Barkley, R. A. (1997). *ADHD and the nature of self-control.* New York: Guilford Press.

Boyles, N. S., & Contadino, D. (1996). *Parenting a child with attention deficit/hyperactivity disorder.* Los Angeles: Lowell House.

Cohen, M. W. (1998). *The attention zone.* Washington, DC: Bruner/Mazel.

Diller, L. H. (1998). *Running on Ritalin: A physician reflects on children, society and performance in a pill.* New York: Bantam Books.

DuPaul, G. J., & Stoner, G. (1994). *ADHD in the schools: Assessment and intervention strategies.* New York: Guilford Press.

Flick, G. L. (1998). *ADD/ADHD behavior-change resource kit.* New York: Simon & Schuster.

Hallowell, E., & Ratey, J. (1994). *Driven to distraction.* New York: Pantheon Books.

Hartmann, T. (1993). *Attention deficit disorder: A different perception.* Novato, CA: Underwood-Miller.

Hartmann, T., & Bowman, J. (1996). *Think fast: The ADD experience.* Grass Valley, CA: Underwood Books.

Ingersoll, B. D. (1998). *Daredevils and daydreamers: New perspectives on attention deficit/hyperactivity disorder.* New York: Doubleday.

Kelly, K., & Ramundo, P. (1993). *You mean I'm not lazy, stupid or crazy.* Cincinnati, OH: Tyrell and Jerem Press.

Koplewicz, H. S. (1996). *It's nobody's fault: New hope and help for difficult children.* New York: Random House.

Lerner, J. W., Lowenthal, B., & Lerner, S. R. (1995). *Attention deficit disorders: Assessment and teaching.* Pacific Grove, CA: Brooks/Cole Publishing.

Lynn, G. T. (1996). *Survival strategies for parenting your ADD child.* Gross Valley, CA: Underwood Books.

McCarney, S. B. (1994). *The attention deficit disorders' intervention manual* (2nd ed.). Columbia, MO: Hawthorne Educational Services.

McEwan, E. (1995). *Attention deficit disorder: Helpful, practical information.* Wheaton, IL: Harold Shaw Publishers.

McEwan, E. (1997). *Managing attention and learning disabilities: Super survival strategies.* Wheaton, IL: Harold Shaw Publishers.

Sears, W., & Thompson, L. (1998). *The A.D.D. book: New understandings, new approaches to parenting your child.* Boston: Little Brown and Company.

Selikowitz, M. (1995). *All about A.D.D.* Melbourne, Australia: Oxford University Press.

Silver, L. B. (1992). *Dr. Larry Silver's advice to parents on attention-deficit hyperactivity disorder.* Washington, DC: American Psychiatric Press.

Silver, L. B. (1999). *Attention-deficit/hyperactivity disorder: A clinical guide to diagnosis and treatment for health and mental health professionals* (2nd ed.). Washington, DC: American Psychiatric Press.

Umansky, W., & Smalley, B. S. (1994). *ADD: Helping your child.* New York: Warner Books.

Weiss, L. (1999). *Give your ADD teen a chance: A guide for parents of teenagers with attention deficit disorder.* Colorado Springs, CO: Pinon Press.

Readings for Children

Corman, C., & Trevino, E. (1995). *Eukee the jumpy, jumpy elephant.* Plantation, Florida: Specialty Press.

Galum, M. (1988). *Otto learns about his medicine.* New York: Magination Press.

Gehret, J. (1991a). *Eagle Eyes: A child's guide to paying attention.* Fairport, NY: Verbal Image Press.

Gehret, J. (1991b). *I'm somebody, too!* Fairport, NY: Verbal Images Press.

Gordon, M. (1991). *I would if I could: A teenager's guide to ADHD/hyperactivity.* Dewitt, NY: GSI.

Gordon, M. (1992). *My brother's a world class pain: A sibling's guide to ADHD.* Dewitt, NY: GSI.

Janover, C. (1997). *Zipper: The kid with ADHD.* Rockville, MD: Woodbine House.

Moss, D. (1989). *Shelley, the hyperactive turtle.* Rockville, MD: Woodbine House.

Nadeau, K. G. (1998). *Help 4 ADD @ high school.* Bethesda, MD: Advantage Books.

Parker, R. (1994). *Making the grade: An adolescent's struggle with ADD.* Plantation, FL: Specialty Press.

Parker, R. (1995). *Slam dunk: A young boy's struggle with ADD.* Plantation, FL: Specialty Press.

Quinn, P., & Stern, J. (1991). *Putting on the brakes: Young people's guide to understanding attention deficit hyperactivity disorder.* New York: Magination Press.

Stern, J., & Ben-Ami, U. (1996). *Many ways to learn: Young people's guide to learning disabilities.* New York: Magination Press.

Internet Resources

Literally hundreds of Internet resources are devoted to ADHD and related issues. We selected the following websites because they are among the most comprehensive and offer links to a wide variety of other sites. In addition, servers such as America On Line, have their own ADHD bulletin boards and newsletters.

One ADD Place
http://www.oneaddplace.com
A "virtual neighborhood" that consolidates information and resources relating to ADD. Features include information, lists of books, tapes and products, FAQ's (frequently asked questions), calendar of events, and other current announcements.

C.H.A.D.D. Online
http://www.cmhc.com/guide/adhd.htm
The website of C.H.A.D.D., the largest national organization of people concerned with ADD. Features include information about advocacy for disability issues in the legislature as well as behavioral checklists, FAQ's, links to online resources and support groups and other organizations.

ExplaintheBrain.com
A learning resource for parents and educators to assist in bridging between education and brain research.

Mental Health Net (MHN)
http://adhd.mentalhelp.net
Created by a psychologist as a free service to mental health professionals, this website includes ADHD among other mental health issues. Features include a comprehensive list of websites that represent various points of view, resources, and lists of organizations.

Organizations

CH.A.D.D. (Children with Attention Deficit Disorders)
8181 Professional Place – Suite 201
Landover, Maryland 20785
(800) 233-4050 (301) 306-7070

The Council for Exceptional Children
1110 North Glebe Road
Arlington, Virginia 22201-5704
(888)-CEC-SPED

The Gifted Learning Disabled Educational Network, Inc.
P.O. Box 30239
Bethesda, Maryland 20824-0239
(301) 986-1422

ADD Resource Catalogue

A.D.D. Warehouse
300 Northwest 70th Avenue, Suite 102
Plantation, Florida 33317
(954) 792- 8944

Research Monograph

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